

1) Beneficiary

A. Phase-I

- Irrigation : Existing Bang Pakong area (12,700ha of irrigable area)
Bang Pakong Expansion area (2,000 ha of irrigable area)

B. Phase-II

- Irrigation : Existing Tha Lat area (22,100 ha of irrigable area)
Tha Lat Expansion area (8,140 ha of irrigable area)

2) Major Facilities

A. Phase -I

- Common Facilities : Bang Pakong diversion dam
- Irrigation System : Pumping station, main canal and related structures, drainage excavation and rehabilitation of regulating structures in the subject irrigable area

B. Phase-II

- Common Facilities : Khlong Si Yat dam
- Irrigation canals : Rehabilitation/construction of main and lateral canals as well as related structures in the subject irrigable area

The project area is located between Bangkok Metropolitan and Eastern Seaboard area as their hinterland. Regional development of the vicinity of the Project area is quite remarkable, especially in the industrial sector.

The government of Thailand decided recently to accelerate water resources development as well as infrastructural development in the said region.

10-2-2. Optimum Construction Schedule

The major work items of the Project consist of the survey/investigation and design, tender procedures inclusive of preparation of tender documents, construction works, procurement of O&M equipments, assistance for construction of on-farm facilities including agricultural extension services, and

consulting services. The time schedule of the respective work items is made based on the concept as follow, and the project implementation schedule is proposed as shown in Figure 10-2.

1) Survey, Investigation and Design

Detailed topographic surveys and geological investigations for proposed storage dams, diversion dam and main canal systems should be started in the first project year.

The detailed design and preparation of the tender documents should preferably be completed within the previous fiscal year of commencement of construction works. Therefore, the design work schedule shall be established in advance of the construction schedule. Preparation of tender document shall also be completed in parallel with design works.

2) Construction Schedule

The construction works will be undertaken on contract basis following the current governmental policy, and will be commenced from the middle of the second project year, taking into consideration the above-mentioned pre-construction works. It is proposed to complete the Project construction works in five years taking into account the Project volume and its construction schedule, staffing capacity of RID, tendency of the budgetary support in Baht and so forth.

3) Procurement of O&M Equipment

Procurement of operation and maintenance equipments will start from the sixth project year, and inspection and inland transportation to the site shall be completed within the same project year.

4) Technical Cooperative Service

Technical cooperative services such as design and construction of on-farm facilities, assistance for establishment of irrigators' association and agricultural extension services will be rendered from the second project year. It is desirable to continue such services even after the completion of the project works.

5) Consulting Services

The consulting services to assist the Thai officials concerned in design, preparation of tender documents and agricultural supporting services shall start at the beginning of the first project year, and the consultants personnel both foreign and local will render services up to provisional takeover of the completed facilities.

FIGURE 10-2 PROJECT IMPLEMENTATION SCHEDULE (1/2) PHASE I PROJECT

Work Description	1991		1992		1993		1994		1995		1996		1997		1998	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
PHASE I PROJECT																
1. Design and Tendering																
1-1. Survey and Design																
1-2. Tendering and Contract																
2. Construction																
2-1. Diversion Dam																
1) Temporary works																
2) Diversion dam body																
- Earth work/piling																
- Concrete works																
- Gate installation																
3) River bed protection																
4) Dike protection																
5) Diversion channel																
6) Closure dam/roads																
2-2. Pumping Station																
1) Temporary works																
2) Civil works																
3) Pump house																
4) Pump installation																
2-3. Intake Canal (0.7 km)																
1) Intake canal																
2) Diversion works																
2-4. Left Main Canal (12.0 km)																
1) Main canal																
2) Structures																
2-5. Right Main Canal (24.0 km)																
1) Main canal																
2) Structures																
2-6. Drainage System																
1) Drainage canal																
2) Dike construction																
3. Land Acquisition																
4. Procurement of O/M Equipment																
5. Technical Assistance for On-farm																

FIGURE 10-2 PROJECT IMPLEMENTATION SCHEDULE (2/2) PHASE II PROJECT

Work Description	1991		1992		1993		1994		1995		1996		1997		1998	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
PHASE II PROJECT																
1. Design and Tendering																
1-1. Survey and Design																
1-2. Tendering and Contract																
2. Construction																
2-1. Khlong Si Yat Dam																
1) Temporary works																
2) Main dam																
- Stripping/excavation																
- Embankment																
3) Spillway																
- Excavation																
- Concrete																
4) Outlet works																
5) Road works																
2-2. Tha Lat Irrigation System																
1) Temporary works																
2) Tha Lat weir																
3) Tha Lat main canal (44 km)																
4) Structures																
- Improvement																
- New construction																
5) Lateral canal																
6) Turn-out																
2-3. Si Yat Irrigation System																
1) Temporary work																
2) Si Yat main canal (49.5 km)																
3) Structures																
4) Lateral canal																
5) Turn-out																
3. Land Acquisition																
4. Procurement of O/M Equipment																
5. Technical Assistance for On-farm																

10-3. Operation and Maintenance

10-3-1. Organization for Operation and Maintenance

Under the chairmanship of RID, water users' association shall be established in order to manage water distribution matters. The proposed organization for operation and maintenance is shown in Figure 10-3.

Three irrigation systems are set up for the proposed Project. The proposed organizations for operation and maintenance of respective systems are illustrated in Figures 10-4, 10-5 and 10-6.

The system office manager will be fully responsible for overall operation and maintenance of the system facilities under the control of the Director, Regional Irrigation Office 9.

Each system has four sections in charge of administration, water control service, engineering service and mechanical engineering. Irrigation system is divided into several area managing sections which are composed of some zone managing units. The area managing section will be responsible for the service area of 5,000 ha ~7,000 ha more or less. The zone managing unit will be responsible for the area of around 1,000 ha more or less.

The area managing section is controlled by water master under the management of the system manager. The zone managing unit is controlled by a zone man with the assistance of several water tenders and canal tenders.

10-3-2. Operation and Maintenance Management

The System Operation Manager will be responsible to make formal and additional reports to the Director of Regional Irrigation Office No.9, Chonburi, regarding the irrigation schedule and facilities maintenance plan, and also responsible to control/review the various works on water utilization programming, repairing and improving of facilities, and so forth.

The Administration Section will be in charge of general matters inclusive of budgeting, accounting, personnel affairs and management of the office properties. The Mechanical Section will be responsible for operation and maintenance of equipments and vehicles, etc., under the office, and formulate a plan for mobilization of equipments. The Engineering Section will be responsible for survey, design, construction and improvement of canals and related facilities inclusive of repairing works.

FIGURE 10-3 ORGANIZATION OF OPERATION AND MAINTENANCE

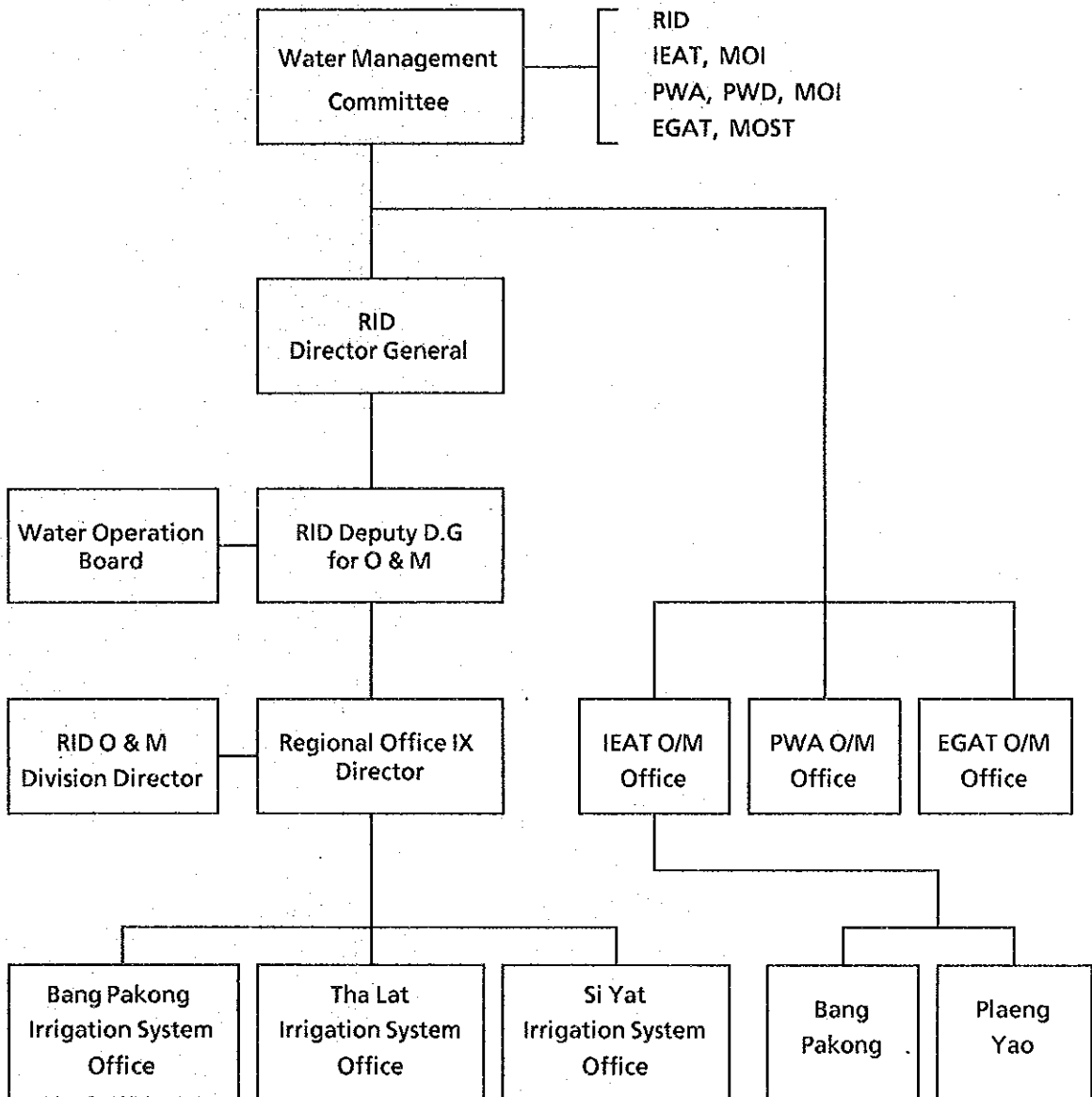


FIGURE 10-4 PROPOSED ORGANIZATIONAL SET UP FOR O & M OF BANG PAKONG IRRIGATION SYSTEM

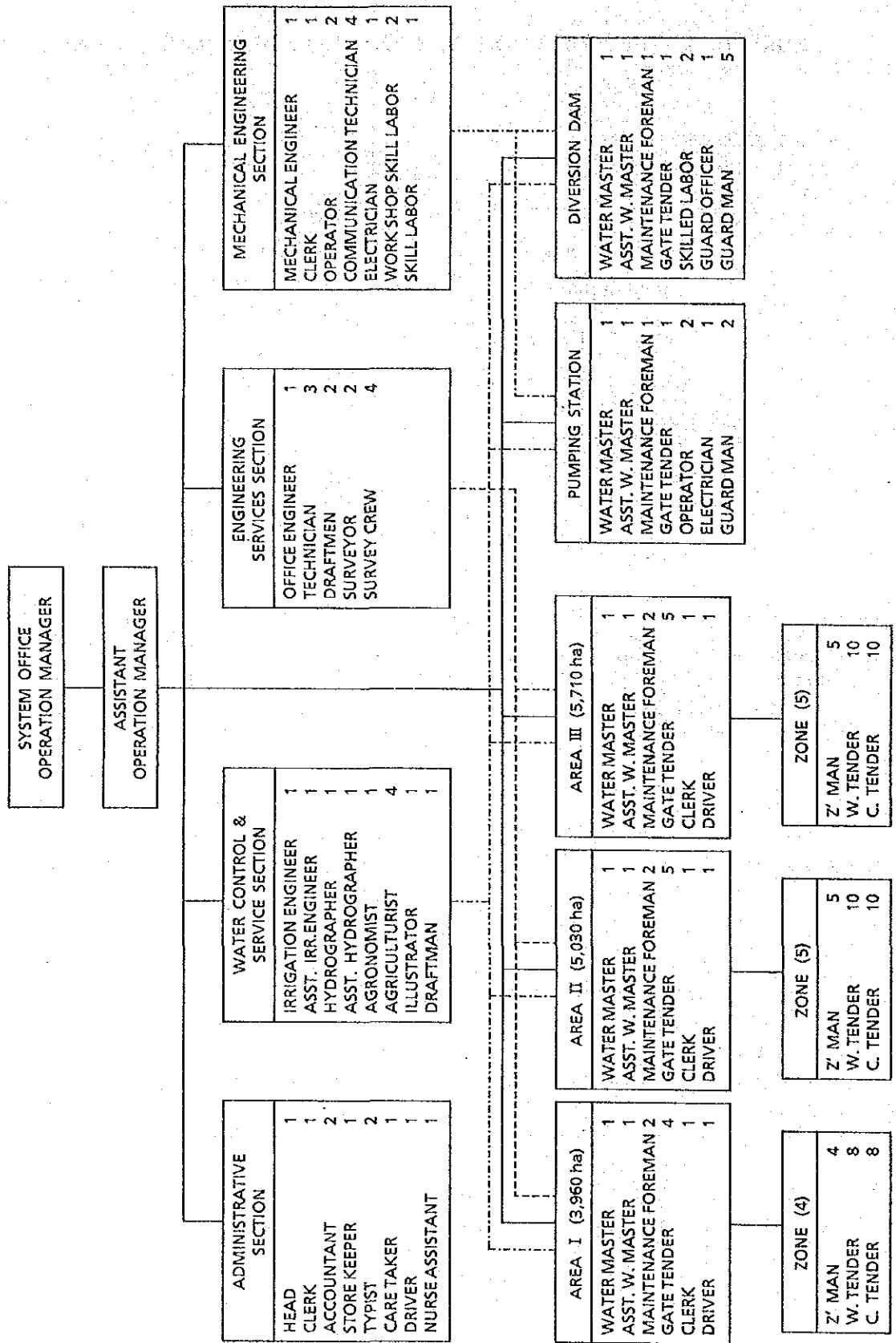


FIGURE 10-5 PROPOSED ORGANIZATIONAL SET UP FOR O & M OF THA LAT IRRIGATION SYSTEM

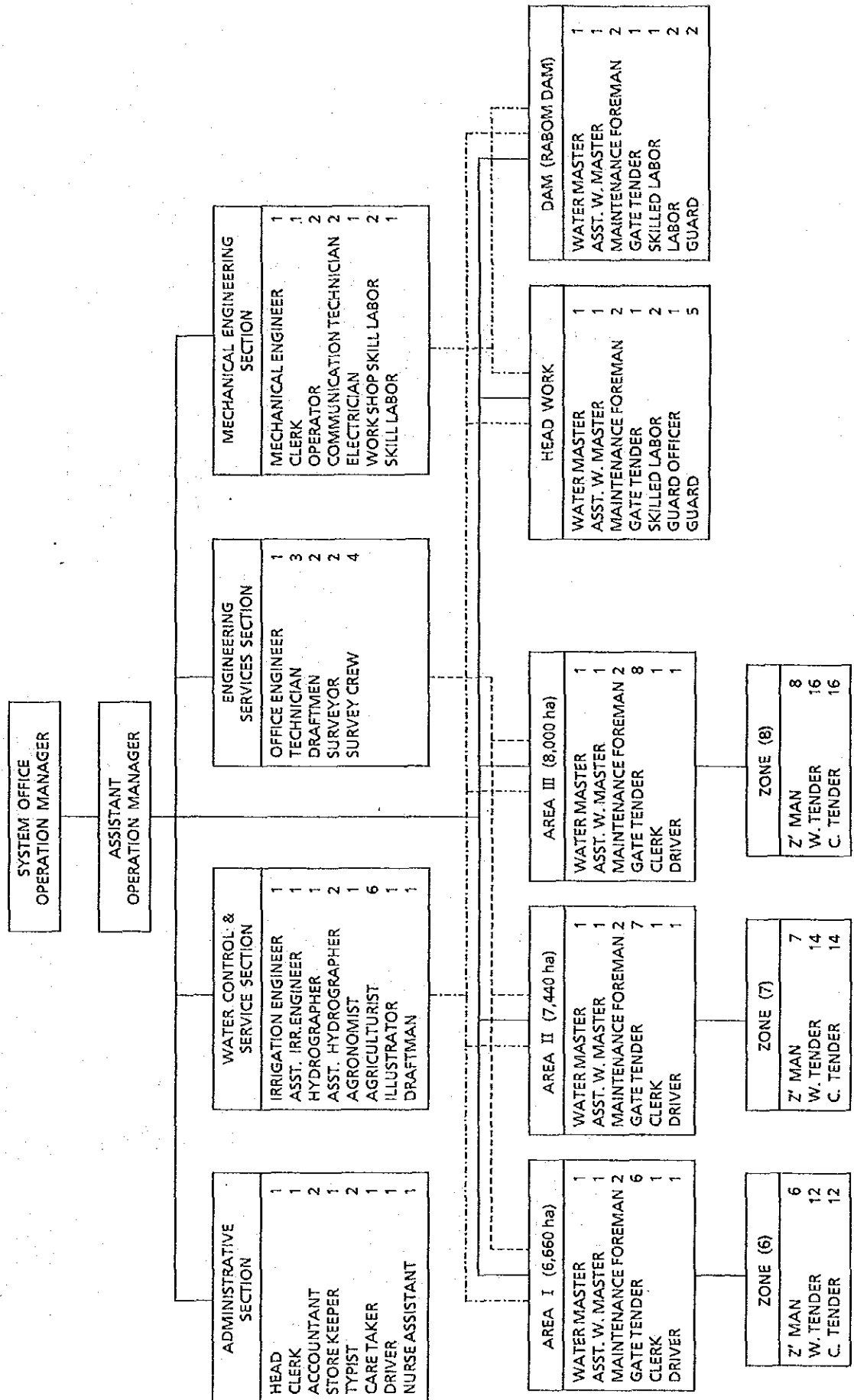
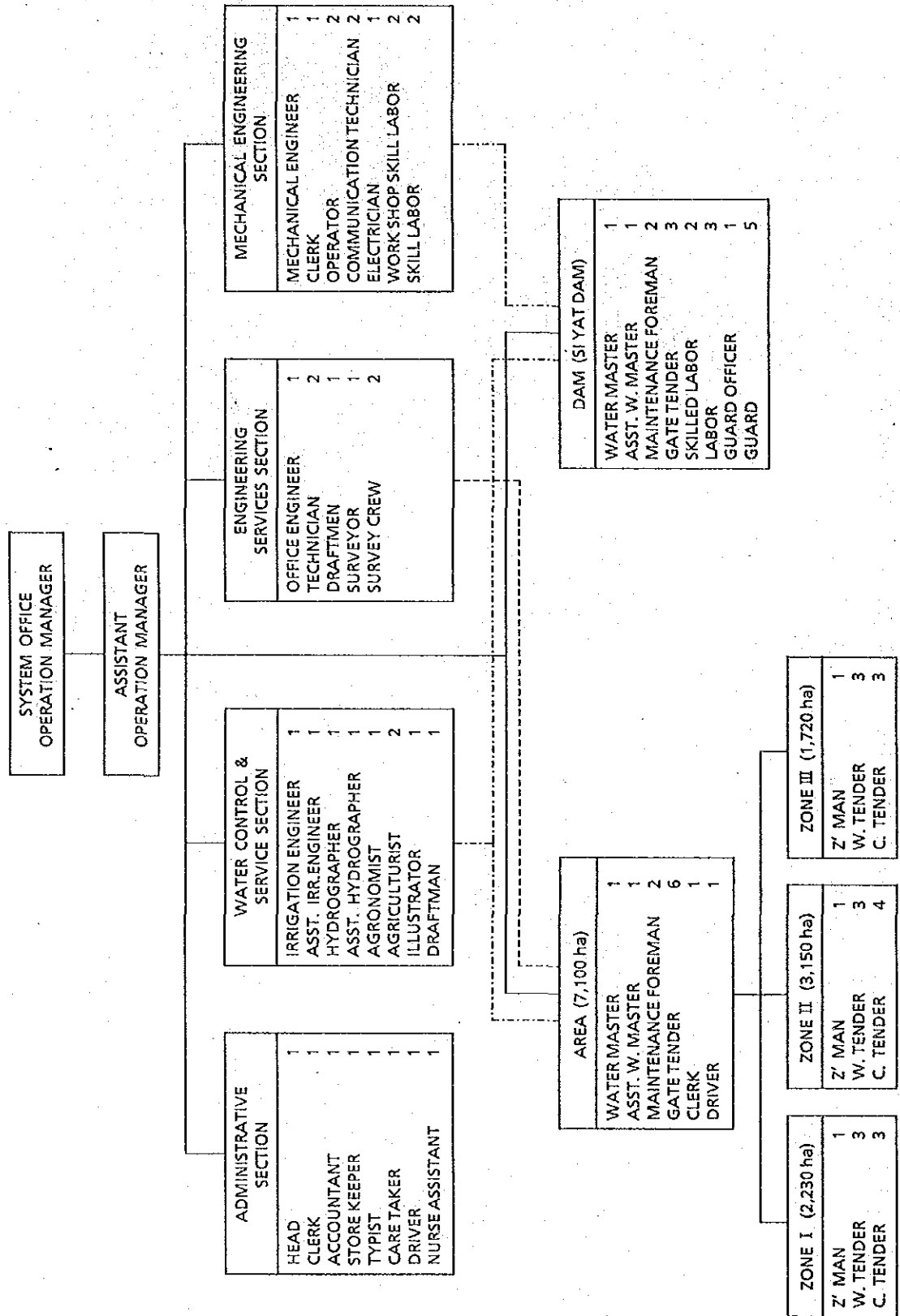


FIGURE 10-6 PROPOSED ORGANIZATIONAL SET UP FOR O & M OF SI YAT IRRIGATION SYSTEM



The Water Control Service Section will be responsible to carry out water management and general O& M of the facilities based on the O & M guideline mentioned below;

The Water Masters assigned to the storage dams, diversion dam, pumping station and each area managing section will be responsible for guidance and supervise the zonemen and common irrigators in the respective areas in charge.

The major tasks are shown below;

- i) In consultation with the Water Control Service Section staff, to determine an irrigation requirement in the area.
- ii) To measure and control the water to be supplied at the diversion points so as to meet the water requirement keeping the losses at a minimum.
- iii) To prepare water release schedule and rules based on the irrigation requirements and cropping patterns furnished by the other Water Masters. (duty of the Water Master in charge of O& M of the dams and pumping station)
- iv) To measure and record the discharges at major distribution points on the supply basis, and prepare discharge data so as to materialize a proper water management systems.

Zonemen and Common Irrigators should assist Water Master in carrying out proper water distribution in the area in charge and in giving guidances to farmers' groups.

10-3-3. Water Management Plan of the Tha Lat River Basin

1) Outline of the Water Storage Facilities and Water Demands/Supply

A) Water Resources Development Plan in the Basin

As discussed previous chapter in the overall basin study, the water resource development plan in the Bang Pakong river basin was divided into three phases by the target year of 2000. The said plan has 12 storage reservoirs with total effective storage volume of 2,304 MCM and the systems can be supplied raw water of about 3,953 MCM per annum to the beneficiaries.

Annual available water of about 787 MCM by the said storage facility and natural river runoff from the river basin can be provided to the respective water consumers of irrigation, industry, drinking water and other sectors.

The development scheme of the Tha Lat river basin consists of following construction works as first phase project in the Bang Pakong river basin.

Facility	Effective Storage Capacity	
	(MCM)	Completion
Rabom Storage Dam	40.0	1990
Khlong Si Yat Storage Dam	300.0	1997
Bang Pakong Diversion Dam	30.0	1995

B) Water Supply Requirement

The beneficiaries of the project and period of raw water supply are summarized as follows:

Beneficiary	Supply Period	
	Required Period	From Storage Facility
Irrigation	Year round except June, December	Irrigation period
Industry, Drinking Fishery, EGAT	Year round	Mainly dry season

C) River Runoff Pattern in the Bang Pakong river Basin

River water level at the proposed Bang Pakong diversion dam is being fluctuated between (+) 1.00 m and (-) 1.00 m above mean sea level (MSL) affecting tidal movement. On the other hand, the water level of upstream of the river will gradually rise up based on river runoff increase with rather complicated function of tidal movement.

Fluctuation of river water level will be affected by in flowing discharge from several number of tributaries, river dikes and cross section of the river, flat farm land along the river channel other than above mentioned situations.

D) Function of the Bang Pakong Diversion Dam

Function of the Bang Pakong diversion dam which will be constructed at the site of around 70 km upstream from the river mouth are summarized as follows;

- To prevent saline water intrusion in dry season and change water quality to fresh water.
- To store/regulate raw water from storage dams and upstream of the river in dry season based on the water management guideline.
- Operation of the gate on diversion dam, as a rule, will be made taking into account of salinity contents of raw water, preservation of fish family, and it will be full open in rainy season and be close in dry season.
- During the transition period between rainy season and dry season (mainly, May to June and November to December), the control water level at the upstream of diversion damsite will be controlled by double leaf roller gates.
- Control water level at the upstream of diversion damsite shall be (+) 1.00 m MSL as maximum and (-) 1.00 m MSL as minimum.

2) Water Management Plan

A) Basic Concept of the Plan

The Project will be implemented dividing into two phases taking into consideration of urgency of water demands and actual construction period. Water management plan, therefore, should be established two phases such as tentative and final plan, respectively.

- | | |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tentative Plan | : Major water resources <ul style="list-style-type: none"> - Rabom storage reservoir - Bang Pakong diversion dam Beneficiaries <ul style="list-style-type: none"> - Irrigable area of 14,700 ha in Bang Pakong left bank area - Industry, domestic water, fishery and EGAT |
| Final Plan | : In addition to the above, Major water resources <ul style="list-style-type: none"> - Khlong Si Yat reservoir Beneficiaries <ul style="list-style-type: none"> - Irrigable area of 30,500 ha in Tha Lat area - Industry and domestic water |

These water management plans should be prepared in consideration of flood control and water utilization of the river, impact of social, natural and environmental aspects in the river basin.

B) Water Management Facility and Arrangement of Information

Since the major intake facility for respective water users concentrate at and around the proposed diversion dam, control system on water management for the Project shall be provided at the proposed diversion damsite. Water release from the Rabom and Khlong Si Yat dam will be made depending upon the diversion dam to keep water level of (+) 1.00 m MSL more or less.

There is some amounts of river runoff from upstream of the diversion dam during transition period of rainy and dry season. Therefore, when imbalance between water demand and supply occurs, adjustment of water release from the storage dams and control gate operation at the diversion damsite will be needed after receiving more detail information on the meteorological and hydrological data and evaluating those data and information.

The following informations, as a minimum requirement, shall be collected at appropriate sites and locations.

- Meteorological and hydrological data/information, such as rainfall, water level at gauging station and discharge at gauging station of NYI in Nakhon Nayok, 3 in Prachin river basin, and reservoir site of Rabom and Khlong Si Yat, Tha Lat diversion weir and proposed diversion damsite.
- Record on the released discharge and spillage at Rabom and Khlong Si Yat damsites.
- Water requirement from beneficiaries.
- Other information related to the operation and maintenance of the facility.

C) Control Water Level at Upstream of Proposed Diversion Dam

As mentioned in the previous section on the water balance study, the control water level at upstream of proposed diversion dam are basically as follows.

- Highest control water level : (+) 1.00 m MSL
- Lowest control water level : (-) 1.00 m MSL
- Control water level at transition period: (+) 0.00 m MSL
- Rainy season : Full open of the gates

D) Operation Rule of the Gate at Diversion Dam

Specifications of the gates are 3 units of flood way gates and 2 units of double leaf type control gates with 30 m span, respectively. The control gates will be operated during transition period based on the results of analysis/evaluation on the meteorological and hydrological data/information collected from the key station in the entire river basin. Operation concepts for the system are safety and easy from the viewpoint of technical and operational aspects.

CHAPTER 11. COST ESTIMATE

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11-1. Basic Concept on Cost Estimate

11-1-1. Basic Concept

The construction works will be conducted on contract basis depending on the governmental policies currently enforced in Thailand. The whole construction works consisting of "Direct Work" conducted by the national government and "Indirect Work" managed by beneficial farmers group are proposed to be completed within 6.0 years for Phase I Project and 6.5 years for Phase II Project, which are estimated taking into account the quantity of works, budgetary support and staffing capability of RID.

The project cost comprises the cost of preparatory work, construction, land acquisition, procurement of O & M equipments, administration, survey and geological investigation, engineering services as well as physical and price contingencies.

The unit cost for construction works includes construction materials, labour and equipment to be used, overhead charges, taxes and profit for the contractor. The cost is estimated on the basis of the prices and manner employed by RID.

As regards foreign and local currency portions for the major construction materials, the following rates are applied:

Materials	Foreign Currency	Local Currency
	(%)	(%)
Cement	60	40
Reinforcement Bar	70	30
Fuel and Oil	80	20
Timber	20	80
Explosive	80	20
Depreciation for Equipment	70	30
Steel Production	90	10
Labour	0	100

The basis of applied unit cost is Thai fiscal year 1990 prices.

11-1-2. Details of Project Cost

1) Preparatory Work

Preparatory work consists of the construction cost of office building, quaters, garage, warehouse and other necessary appurtenant facilities.

2) Construction Cost

This item includes the construction costs for the Project which are estimated based on the respective unit costs including construction materials, fuel and oil, labour, and depreciation and repairing costs of the construction equipment. The civil works are composed of the followings;

A) Phase I Project

- **Diversion Dam:** comprises excavation work of dambody, foundation treatment, concrete work of dambody, installation of gates, river bed protection, dike protection, connecting bridge, excavation of diversion channel, construction of closure dam and connecting road.
- **Pumping Station:** comprises suction and discharge basin, pump house, pumping plants and related devices.
- **Main Canal:** comprises intake canal, diversion work, left main canal, right main canal, check gates and other facilities, head gates and appurtenant structures.
- **Drainage Canal:** comprises the drainage excavation and regulating gates.

B) Phase II Project

- **Storage Dam:** comprises diversion tunnel, foundation treatment, embankment of dambody, spillway, intake facility, and access road
- **Diversion Weir:** comprises improvement of weir, installation of rubber gate and related devices.
- **Tha Lat Irrigation System:** comprises improvement of main and lateral canals, improvement of related structures such as siphon, culvert, check etc., head gate and appurtenant facilities, turn-out, etc.

- Si Yat Irrigation System: comprises construction of main and lateral canals, appurtenant structures, head gates and turn-out, etc.

3) Land Acquisition

This item includes the cost required to purchase or compensate the land to be occupied by the proposed diversion dam, storage dam and reservoir, main and lateral canals, pumping station, etc., and also to promote reforestation of adjacent area outside of the new reservoir, and the resettlement cost for the inhabitants within the proposed reservoir area.

4) Operation and Maintenance Equipment

This item includes procurement of equipment for the post project operation/maintenance such as motor grader, backhoe, truckcrane, truck and vehicles etc. The cost of equipment and spare parts is estimated based on CIF Bangkok including inland transportation cost of them.

5) Survey and Geological Investigation

This item includes the cost for topographical survey, geological investigation and analysis.

6) Administration Cost

This item includes remuneration for the personnel of the project organization, fuel and oil for the project office, purchase of office equipment and materials, etc.

7) Engineering Services

This cost includes consulting fees for detailed design of the proposed facilities and construction supervision, survey and investigation cost to be undertaken by RID and the cost for overseas training of the governmental officials concerned. It is estimated at about 10% of the above mentioned construction cost taking into account the actual costs required in the similar projects.

8) Physical Contingency

The allocation of contingency is made to cover minor differences between the actual and estimated quantities, unexpected difficulties in construction works and so forth. The contingency equivalent to 10% of the above-mentioned items has been employed.

9) Price Escalation

The annual rate for the foreign currency is based on the G-5 Manufactures Exported Goods Index, IBRD. According the mentioned data, the annual rate of 1991 is expected at 1.43%, it will become 5.18% in 1995 and 4.37% in 1998.

While the annual rate for the local currency is assumed as 5.3% depending on the CPI ratio of 6.5% during 1985 ~1990 (First quarter), it will be expected at stable ratio of 4.5% in 1998.

11-2. Investment Cost

11-2-1. Total Investment Cost

The total project cost for both the Direct and Indirect Project, including the cost for price escalation but excluding the interest during the construction period, is estimated at 3,999 million Baht (equivalent to US\$155 million) which is composed of 2,215 million Baht of foreign currency component and 1,784 million Baht of local currency component for the Phase I Project, while 4,804 million Baht (equivalent to US\$186 million) which is composed of 1,980 million Baht of foreign currency component and 2,824 million Baht of local component for the Phase II Project.

The total investment cost for both of the Phase Projects is 8,803 million Baht (equivalent to US\$ 341 million) which is composed of about 4,195 million Baht of foreign currency component and about 4,608 million Baht of local currency component. The summary of the Project Cost is shown in Table 11-1 and the detail is shown in Table 11-2.

11-2-2. Disbursement Schedule

The disbursement schedule for both the direct and indirect project cost is estimated as shown in Table 11-3 depending on the investment schedule of the Projects. And detailed schedules for the Phase I Project and the Phase II Project are shown in Table 11-4 and Table 11-5.

TABLE 11-1 SUMMARY OF PROJECT COST

- Unit : Million baht

<u>Work Description</u>	<u>Phase I Project</u>	<u>Phase II Project</u>	<u>Total</u>
A. Direct Project Cost			
1. Preparatory Work	20	26	46
2. Construction Cost	2,160	1,943	4,103
3. Land Acquisition / Resettlement	375	680	1,055
4. O & M Equipment	11	11	22
5. Survey and Investigation	24	15	39
6. Administration Cost	106	130	236
7. Engineering Service	216	194	410
8. Physical Contingency	291	299	590
Total (1 - 8)	3,203	3,298	6,501

9. Price Escalation	474	803	1,277
Total (1 - 9)	3,677	4,101	7,778

B. Indirect Project Cost			
1. Construction Cost	220	452	672
2. Engineering Cost	26	54	80
3. Physical Contingency	25	50	75
Total (1 - 3)	271	556	827

4. Price Escalation	51	147	198
Total (1 - 4)	322	703	1,025

Grand Total (A + B)	3,999	4,804	8,803
Foreign Currency	(2,215)	(1,980)	(4,195)
Local Currency	(1,784)	(2,824)	(4,608)

- Unit : 1,000 Baht -

TABLE 11-2 PROJECT COST

Cost Item	Phase I Project			Phase II Project			Total		
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
A. Direct Project Cost									
1. Preparatory Work	5,045	14,955	20,000	6,440	19,560	26,000	11,485	34,515	46,000
2. Construction Cost									
2.1 Storage Dam	-	-	-	562,000	498,000	1,060,000	562,000	498,000	1,060,000
2.2 Diversion Dam	1,200,000	470,000	1,670,000	-	-	-	1,200,000	470,000	1,670,000
2.3 Pumping Station	103,004	39,996	143,000	-	-	-	103,004	39,996	143,000
2.4 Irrigation System	118,318	142,682	261,000	431,450	45,550	883,000	549,768	594,232	1,144,000
2.5 Drainage System	44,738	41,262	86,000	-	-	-	44,738	41,262	86,000
Sub - Total	1,466,060	693,940	2,160,000	993,450	949,550	1,943,000	2,459,510	1,643,490	4,103,000
3. Land Acquisition/Resettlement and Compensation	-	375,000	375,000	-	680,000	680,000	-	1,055,000	1,055,000
4. O & M Equipment	8,802	2,198	11,000	9,040	2,260	11,300	17,842	4,458	22,300
5. Survey and Investigation	11,362	12,438	23,800	7,862	6,738	14,600	19,224	19,176	38,400
6. Administration	-	106,000	106,000	-	130,000	130,000	-	236,000	236,000
7. Engineering Service	146,600	69,400	216,000	135,800	58,200	194,000	282,400	127,600	410,000
Total (1 - 7)	1,637,869	1,273,931	2,911,800	1,152,592	1,846,308	2,998,900	2,790,461	3,120,239	5,910,700
8. Physical Contingency	164,131	127,069	291,200	115,408	183,692	299,100	279,539	310,761	590,300
Total (1 - 8)	1,802,000	1,401,000	3,203,000	1,268,000	2,030,000	3,298,000	3,070,000	3,431,000	6,501,000
9. Price escalation	216,000	258,000	474,000	280,000	523,000	803,000	496,000	781,000	1,277,000
Total (1 - 9)	2,018,000	1,659,000	3,677,000	1,548,000	2,553,000	4,101,000	3,566,000	4,212,000	7,778,000
B. Indirect Project Cost									
1. On-Farm Facilities	138,285	81,715	220,000	285,175	166,825	452,000	423,460	248,540	672,000
2. Engineering Cost	16,340	9,660	26,000	34,070	19,930	54,000	50,410	29,590	80,000
Total (1 - 2)	154,625	91,375	246,000	319,245	186,755	506,000	473,870	278,130	752,000
3. Physical Contingency	15,375	9,625	25,000	31,755	18,245	50,000	47,130	27,870	75,000
Total (1 - 3)	170,000	101,000	271,000	351,000	205,000	556,000	521,000	306,000	827,000
4. Price Escalation	27,000	24,000	51,000	81,000	66,000	147,000	108,000	90,000	198,000
Total (1 - 4)	197,000	125,000	322,000	432,000	271,000	703,000	629,000	396,000	1,025,000
Grand Total (A + B)	2,215,000	1,784,000	3,999,000	1,980,000	2,824,000	4,804,000	4,195,000	4,608,000	8,803,000

TABLE 11-3 SUMMARY OF DISBURSEMENT SCHEDULE

- Unit : Million Baht -

Project Year	Phase I Project			Phase II Project			Total			
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	
A. Direct Project Cost										
1991	56.3	157.0	213.3	-	-	-	56.3	157.0	213.3	2.7
1992	195.3	251.5	446.8	51.2	455.6	506.8	246.5	707.1	953.6	12.3
1993	702.0	481.0	1,183.0	113.5	371.3	484.8	815.5	852.3	1,667.8	21.4
1994	635.6	399.2	1,034.8	213.9	288.8	502.7	849.5	688.0	1,537.5	19.8
1995	326.4	250.1	576.5	357.5	479.4	836.9	683.9	729.5	1,413.4	18.2
1996	102.6	120.1	222.7	485.2	593.5	1,078.7	587.8	713.6	1,301.4	16.7
1997	-	-	-	277.8	303.4	581.2	277.8	303.4	581.2	7.5
1998	-	-	-	48.9	60.8	109.7	48.9	60.8	109.7	1.4
Total	2,018.2	1,658.9	3,677.1	1,548.0	2,552.8	4,100.8	3,566.2	4,211.7	7,777.9	100.0
B. Indirect Project Cost										
1991	2.7	1.6	4.3	-	-	-	2.7	1.6	4.3	0.4
1992	29.8	18.6	48.4	5.5	3.5	9.0	35.3	22.1	57.4	5.6
1993	31.4	19.7	51.1	39.8	25.1	64.9	71.2	44.8	116.0	11.3
1994	33.3	20.8	54.1	78.1	49.1	127.2	111.4	69.9	181.3	17.7
1995	35.0	21.9	56.9	82.1	51.3	133.9	117.1	73.7	190.8	18.6
1996	64.8	42.4	107.2	86.1	54.3	140.4	150.9	96.7	247.5	24.2
1997	-	-	-	89.8	56.8	146.6	89.8	56.8	146.6	14.3
1998	-	-	-	50.6	30.4	81.0	50.6	30.4	81.0	7.9
Total	197.0	125.0	322.0	432.0	271.0	703.0	629.0	396.0	1,025.0	100.0
Grand Total	2,215.2	1,783.9	3,999.1	1,980.0	2,823.8	4,803.8	4,195.2	4,607.7	8,802.9	

TABLE 11-4 DISBURSEMENT SCHEDULE OF PROJECT COST (Phase I Project) 1/2

Unit : Baht '000

Description	Total			1991			1992			1993		
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
A. Direct Project Cost												
1. Preparatory Work	5,045	14,955	20,000	-	-	-	5,045	14,955	20,000	-	-	-
2. Construction Cost												
2.1 Diversion Dam	1,200,000	470,000	1,670,000	-	-	-	133,773	56,515	190,288	547,867	224,007	771,874
2.2 Pumping Station	103,004	39,996	143,000	-	-	-	-	-	-	-	-	-
2.3 Irrigation System	118,318	142,682	261,000	-	-	-	-	-	-	21,015	24,580	45,595
2.4 Drainage System	44,738	41,262	86,000	-	-	-	-	-	-	-	-	-
Sub - Total	1,466,060	693,940	2,160,000	-	-	-	133,773	56,515	190,288	568,882	248,587	817,469
3. Land Acquisition/Resettlement and Compensation	-	375,000	375,000	-	100,000	100,000	-	100,000	100,000	-	95,000	95,000
4. O & M Equipment	8,802	2,198	11,000	-	-	-	-	-	-	-	-	-
5. Survey and Investigation	11,362	12,438	23,800	6,800	7,400	14,200	4,562	5,038	9,600	-	-	-
6. Administration	-	106,000	106,000	-	10,000	10,000	-	18,000	18,000	-	22,000	22,000
7. Engineering Services	146,600	69,400	216,000	44,000	20,800	64,800	29,300	13,900	43,200	22,000	10,400	32,400
Total (1 - 7)	1,637,869	1,273,931	2,911,800	50,800	138,200	189,000	172,680	208,408	381,088	590,882	375,987	966,869
8. Physical contingency	164,131	127,069	291,200	5,080	13,820	18,900	17,268	20,840	38,108	59,088	37,598	96,686
Total (1 - 8)	1,802,000	1,401,000	3,203,000	55,880	152,020	207,900	189,948	229,248	419,196	649,970	413,585	1,063,555
9. Price Escalation	216,000	258,000	474,000	391	5,016	5,407	5,318	22,237	27,555	51,997	67,414	119,411
Grand Total	2,018,000	1,659,000	3,627,000	56,271	157,036	213,307	195,266	251,485	446,751	701,967	480,999	1,182,966
B. Indirect Project Cost												
1. On-Farm Facilities	138,285	81,715	220,000	-	-	-	24,000	14,000	38,000	24,000	14,000	38,000
2. Engineering Cost	16,340	9,660	26,000	2,400	1,400	3,800	2,400	1,400	3,800	2,400	1,400	3,800
Total (1 - 3)	154,625	91,375	246,000	2,400	1,400	3,800	26,400	15,400	41,800	26,400	15,400	41,800
3. Physical Contingency	15,375	9,625	25,000	240	140	380	2,640	1,540	4,180	2,640	1,540	4,180
Total (1 - 3)	170,000	101,000	271,000	2,640	1,540	4,180	29,040	16,940	45,980	29,040	16,940	45,980
4. Price Escalation	27,000	24,000	51,000	18	51	69	813	1,643	2,456	2,323	2,761	5,084
Grand Total	197,000	125,000	322,000	2,658	1,591	4,249	29,853	18,583	48,436	31,363	19,701	51,064

TABLE 11-4 DISBURSEMENT SCHEDULE OF PROJECT COST (Phase I Project) 2/2

Unit : Baht '000

Description	1994			1995			1996		
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
A. Direct Project Cost									
1. Preparatory Work	-	-	-	-	-	-	-	-	-
2. Construction Cost									
2.1 Diversion Dam	394,604	125,418	520,022	123,756	64,060	187,816	-	-	-
2.2 Pumping Station	58,196	24,099	82,295	44,808	15,897	60,705	-	-	-
2.3 Irrigation System	26,797	32,014	58,811	40,377	48,976	89,353	30,129	37,112	67,241
2.4 Drainage System	2,237	2,063	4,300	22,369	20,631	43,000	20,132	18,568	38,700
Sub - Total	481,834	183,594	665,428	231,310	149,568	380,878	50,261	55,680	105,941
3. Land Acquisition/Resettlement and Compensation	-	80,000	80,000	-	-	-	-	-	-
4. O & M Equipment	-	-	-	-	-	-	8,802	2,198	11,000
5. Survey and Investigation	-	-	-	-	-	-	-	-	-
6. Administration	-	21,000	21,000	-	19,000	19,000	-	16,000	16,000
7. Engineering Services	21,900	10,500	32,400	14,700	6,900	21,600	14,700	6,900	21,600
Total (1 - 7)	503,734	295,094	798,828	246,010	175,468	421,478	73,763	80,778	154,541
8. Physical contingency	50,373	29,509	79,882	24,601	17,546	42,147	7,721	7,756	15,473
Total (1 - 8)	554,107	324,603	878,710	270,611	193,014	463,625	81,484	88,534	170,014
9. Price Escalation	81,454	74,658	156,112	55,746	57,132	112,878	21,094	31,543	52,637
Grand Total	635,561	399,261	1,034,822	326,357	250,146	576,503	102,578	120,073	222,651
B. Indirect Project Cost									
1. On-Farm Facilities	24,000	14,000	38,000	24,000	14,000	38,000	42,285	27,715	68,000
2. Engineering Cost	2,400	1,400	3,800	2,400	1,400	3,800	4,340	2,660	7,000
Total (1 - 3)	26,400	15,400	41,800	26,400	15,400	41,800	46,625	28,375	75,000
3. Physical Contingency	2,640	1,540	4,180	2,640	1,540	4,180	4,575	3,325	7,900
Total (1 - 3)	29,040	16,940	45,980	29,040	16,940	45,980	51,200	31,700	82,900
4. Price Escalation	4,269	3,896	8,165	5,982	5,014	10,996	13,595	10,635	24,230
Grand Total	33,309	20,836	54,145	35,022	21,954	56,976	64,795	42,335	107,130

TABLE 11-5 DISBURSEMENT SCHEDULE OF PROJECT COST (Phase II Project) 1/2

Unit: Baht '000

Description	Total			1992			1993			1994		
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
	A. Direct Project Cost											
1. Preparatory Work	6,440	19,560	26,000	-	-	-	6,440	19,560	26,000	-	-	-
2. Construction Cost	562,000	498,000	1,060,000	-	-	-	36,000	24,000	60,000	82,387	48,111	130,498
2.1 Storage Dam	253,076	264,924	518,000	-	-	-	22,750	22,350	45,100	43,769	54,956	98,725
2.2 Tha Lat Irrigation	178,374	186,626	365,000	-	-	-	-	-	-	29,811	32,600	62,411
2.3 Si Yat Irrigation	993,450	949,550	1,943,000	-	-	-	58,750	46,350	105,100	155,967	135,667	291,634
Sub - Total	-	-	-	-	-	-	-	-	-	-	-	-
3. Land Acquisition/Resettlement and Compensation	-	680,000	680,000	-	340,000	340,000	-	190,000	190,000	-	50,000	50,000
B. Indirect Project Cost												
4. O & M Equipment	9,040	2,260	11,300	-	-	-	-	-	-	-	-	-
5. Survey and Investigation	7,862	6,738	14,600	4,700	4,000	8,700	3,162	2,738	5,900	-	-	-
6. Administration	-	130,000	130,000	-	16,000	16,000	-	20,000	20,000	-	22,000	22,000
7. Engineering Services	135,800	58,200	194,000	40,600	17,600	58,200	27,200	11,600	38,800	13,600	5,800	19,400
Total (1-7)	1,149,592	1,846,308	2,995,900	45,300	377,600	422,900	95,552	290,248	385,800	169,567	213,467	383,034
8. Physical contingency	115,408	183,692	299,100	4,530	37,760	42,290	9,555	29,024	38,579	16,956	21,346	38,302
Total (1-8)	1,268,000	2,030,000	3,298,000	49,830	415,360	465,190	105,107	319,272	424,379	186,523	234,813	421,336
9. Price Escalation	280,000	523,000	803,000	1,395	40,290	41,685	8,408	52,040	60,448	27,418	54,006	81,424
Grand Total	1,548,000	2,553,000	4,101,000	51,225	455,650	506,875	113,515	371,312	484,827	213,941	288,819	502,760
B. Indirect Project Cost												
1. On-Farm Facilities	285,175	166,825	452,000	-	-	-	28,600	16,700	45,300	57,000	33,400	90,400
2. Engineering Cost	34,070	19,930	54,000	4,900	2,900	7,800	4,900	2,900	7,800	4,900	2,900	7,800
Total (1-3)	319,245	186,755	506,000	4,900	2,900	7,800	33,500	19,600	53,100	61,900	36,300	98,200
3. Physical Contingency	31,755	18,245	50,000	490	290	780	3,350	1,960	5,310	6,190	3,630	9,820
Total (1-3)	351,000	205,000	556,000	5,390	3,190	8,580	36,850	21,560	58,410	68,090	39,930	108,020
4. Price Escalation	81,000	66,000	147,000	151	309	460	2,948	3,514	6,462	10,009	9,184	19,193
Grand Total	432,000	271,000	703,000	5,541	3,499	9,040	39,798	25,074	64,872	78,099	49,114	127,213

TABLE 11-5 DISBURSEMENT SCHEDULE OF PROJECT COST (Phase II Project) 2/2

Unit : Baht '000

Description	1995			1996			1997			1998		
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
A. Direct Project Cost												
1. Preparatory Work												
2. Construction Cost												
2.1 Storage Dam	143,391	142,960	286,351	221,199	202,968	424,167	79,023	79,961	158,984	-	-	-
2.2 Tha Lat Irrigation	64,530	69,231	133,761	64,530	69,231	133,761	46,827	43,479	90,306	10,670	5,677	16,347
2.3 Si Yat Irrigation	42,951	44,332	87,283	44,644	46,436	91,080	42,951	44,332	87,273	18,017	18,926	36,943
Sub - Total	250,872	256,523	507,395	330,373	318,635	649,008	168,801	167,772	336,573	28,687	24,603	53,290
3. Land Acquisition/Resettlement and Compensation	-	50,000	50,000	-	50,000	50,000	-	-	-	-	-	-
4. O & M Equipment	-	-	-	-	-	-	9,040	2,260	11,300	-	-	-
5. Survey and Investigation	-	-	-	-	-	-	-	-	-	-	-	-
6. Administration	18,600	7,800	26,400	18,600	7,800	26,400	13,600	5,800	19,400	3,600	1,800	5,400
7. Engineering Services	269,472	336,323	605,795	348,973	396,435	745,408	191,441	193,832	385,273	32,287	38,403	70,690
Total (1 - 7)	26,947	33,632	60,579	34,897	39,643	74,540	19,144	19,383	38,527	3,379	2,904	6,283
8. Physical contingency	296,419	369,955	666,374	383,870	436,078	819,948	210,585	213,215	423,800	35,666	41,307	76,973
Total (1 - 8)	61,061	109,506	170,567	101,340	157,424	258,764	67,176	90,189	157,365	13,202	19,545	32,747
9. Price Escalation	357,480	479,461	836,941	485,210	593,502	1,078,712	277,761	303,404	581,165	48,868	60,852	109,720
Grand Total	57,000	33,400	90,400	57,000	33,400	90,400	57,000	33,400	90,400	28,575	16,525	45,100
B. Indirect Project Cost												
1. On-Farm Facilities	4,900	2,900	7,800	4,900	2,900	7,800	4,900	2,900	7,800	4,670	2,530	7,200
2. Engineering Cost	61,900	36,300	98,200	61,900	36,300	98,200	61,900	36,300	98,200	33,245	19,055	52,300
Total (1 - 3)	6,190	3,630	9,820	6,190	3,630	9,820	6,190	3,630	9,820	3,155	1,475	4,630
3. Physical Contingency	68,090	39,930	108,020	68,090	39,930	108,020	68,090	39,930	108,020	36,400	20,530	56,930
Total (1 - 3)	14,027	11,819	25,846	17,976	14,415	32,391	21,721	16,890	38,611	14,168	9,869	24,037
4. Price Escalation	82,117	51,749	133,866	86,066	54,345	140,411	89,811	56,820	146,631	50,568	60,399	80,967
Grand Total												

CHAPTER 12. PROJECT JUSTIFICATION

CHAPTER 12. PROJECT JUSTIFICATION

12-1. General

12-1-1. General Concept

The project justification is made through the study of project feasibility from economic, financial and socio-economic aspects.

The economic feasibility is studied by calculating the economic internal rate of return (EIRR). Sensitivity analysis is made in order to elucidate the economic viability of the project against the changes in prices, delay in implementation, cost overrun, and target yield behind.

Financial analysis is made by typical farm budget analysis and cost recovery including joint cost allocation.

The socio-economic impacts from the implementation of the Project are treated in intangible benefit study.

12-1-2. Beneficiaries

In order to decide optimum scale of water resources development in Bang Pakong river basin, economic justification for four cases of alternative irrigation plans was carried out in using the cost-benefit ratio method. The alternative irrigation plan-2 including the Tha Lat River basin development project (the Feasibility study Project) was selected as the optimum plan. As a result, the plan recommended is the alternative-2 in which water demand by four beneficiaries of irrigation with crop intensity of 150%, industry, drinking and fishery meets to the full reservoir capacities of the Bang Pakong diversion dam (30 MCM), Si Yat (300 MCM) and Rabom (40 MCM) dams.

The results from the alternative study have been led to selection of the proposed development for an area of 42,500 ha (265,625 rai) of irrigable area, water demand for fishery, domestic and industry of 19.1, 16.9 and 180.0 MCM respectively. The beneficiaries include around 14,800 farm-household, domestic water user of about 310,000 persons, Bang Pakong Industrial Estate with 1,600 ha (10,000 rai) and Plaeng Yao Industrial Estate with 1,600 ha (10,000 rai) and some small factories.

The irrigable areas of 42,500 ha are divided into four sub-project areas, Existing Bang Pakong area of 12,300 ha, Bang Pakong Expansion area of 2,000 ha, Existing Tha Lat area of 21,100 ha and Tha Lat Expansion area of 7,100 ha.

12-2. Methodology

In advance of analysis for project justification, the following basic factors are taken into consideration.

- 1) The project implementation schedule is divided into two phases. The project period of each phase will be six (6) to six and half (6.5) years including one-half to two (2) years for detailed design and five (5) years for tender/construction works. As implementation of two phases is overlapped, the construction period of total projects will be seven and half (7.5) years.
- 2) The economic life of the project will be 50 years.
- 3) All prices are expressed in constant price with fiscal year of 1990 in Thailand.
- 4) The exchange rate of US\$1.00 = 25.80 baht = ¥ 155 on an average for a period from April 1 to June 30, 1990 is used throughout, the study.
- 5) Economic justification for project is made on the agricultural sector including fisheries, and on the other sectors including industrial and drinking water.
- 6) Economic justification in the agricultural sector including fisheries is made on Phase-I, Phase-II and overall project, respectively.
- 7) As tentative case, economic justification is studied on tentative Phase-I exclusive of water volume to be supplemented from Si Yat dam.

12-2-1. Economic Analysis

Economic analysis on project justification is started by determining of economic values obtained through adjustment of financial prices. Adjusting financial prices to economic value are divided into two steps: (1) adjustment for direct transfer payment, (2) adjustment for price distortions.

As the first step, the direct transfer payment is eliminated in adjusting financial prices to economic values. The common transfer payment is taxes, direct subsidies, and credit transactions that include loans, repayment of principal and interest payment. The direct transfer payment is payments that

represent not the use of real resources but only the transfer of claims to real resources from one person in the society to another.

As the second step, the financial price of any goods or services is changed to the shadow price. The shadow price is estimated through adjustment of financial prices to economic values.

Goods and services related to project costs and to benefits are divided by traded items and non-traded items.

The prices for traded goods in project analysis are represented as the CIF prices for imports and the FOB prices for exports in using the international currency unit. These prices are considered as shadow prices without price distortion. The prices are forecasted in 1995 as mid year and in 2000 target year. Financial prices for non-traded goods are adjusted to economic price/border price in order to eliminate price distortion.

1) Conversion Factors

The Standard Conversion Factor of 0.92 is applied to the price of non-traded goods and services. This figure is recommended by IBRD to be adopted in Thailand. The conversion factors by sectors are 0.94 for consumption goods, 0.84 for capital goods, 0.90 for construction and 0.87 for transportation.

2) Economic Prices for Agricultural Inputs and Outputs

For rice, maize, soybean, and fertilizers of traded goods, IBRD forecasted an international market prices in the year of 2000 in the Office Memorandum, the Half-July revision of commodity price forecasting and quarterly review of commodity markets - June 1989.

And the economic prices of input and output materials mentioned above are estimated on the basis of the prices forecasted by IBRD. (Ref. to Appendix I-3-1)

Mungbean and cassava are also traded goods. Their economic prices are estimated on the basis of up-dated FOB, Bangkok.

The financial prices of non-traded goods excluding labor are converted to an equivalent border price in using Standard Conversion Factor.

3) Economic Opportunity Cost of Farm Labor

Pricing of farm labor is the assessment of the opportunity cost. The opportunities are categorized into four opportunities, the opportunity for off-farm employment, (Point A), the farm work season as usual (non-peak period

(Point B), the full employment peak period (Point C) and an attractive opportunity to be hired in labor market outside the Project area (Point D).

The marginal opportunity cost of labor supplied for farm work in the Project area can be represented by an "S-shaped curve" which is drawn by using the marginal opportunity cost estimated at four points correspond to four opportunities mentioned above. The marginal opportunity cost is estimated at eight Baht of Point A, 33 Baht of Point B, 66 baht of Point C and 100 baht of Point D. Shadow wage rate is estimated at 45% (30 Baht/66 Baht). (Ref. to Appendix I-3-2)

4) Construction Conversion Factor

The Conversion Factor for construction cost is represented at 0.90 as mentioned above. This Conversion Factor is able to be broken to figures by cost component by using conversion factor of transfer payment and unskilled labor.

5) Valuing Land

The opportunity cost of land is the net value of production forgone when the use of the land is changed from its without-project use to its with-project use.

12-2-2. Financial Analysis

The subjects studied in the financial analysis are farm budget analysis, cost recovery and joint cost allocation.

1) Farm Budget Analysis

Farm budget analysis is started by selection of typical farms by sub-project area. Cropping system in both sub-project area of Existing Bang Pakong and Bang Pakong Expansion are the same orchard production area. On the other hand, though main crop in Existing Tha Lat area is paddy, those in Tha Lat Expansion area are paddy and orchard. Hence, typical farms are selected from three sub-project area of Existing Bang Pakong, Existing Tha Lat and Tha Lat Expansion. Average size of typical farm is estimated based on the Socio-economic data in 1987, NSO.

Net farm income with/without the project are obtained by deduction of production cost from gross farm income using financial prices of commodities. Crop income is estimated based on the cropping pattern proposed. Livestock income is estimated by use of the results of the Socio-agro Economic Survey conducted by RID in 1989. Off-farm income and family labor cost are excluded.

It is assumed that beneficial farmers pay the water charge and bear the cost of the on-farm work. The water charge is estimated from operation and maintenance cost. The Government will bear the operation and maintenance cost of facilities constructed through disbursement of the direct project cost. Hence, the operation and maintenance costs of on-farm facilities will be paid by beneficial farmer as water charge. The capital to be used as cost of on-farm work will be borrowed from the BAAC's long term loan.

Annual repayment cost and water charge are secured from incremental net farm income per farm. The upper limit ratio of the repayment cost is assumed as 40% of the incremental net farm income. This ratio is marginal saving propensity.

2) Cost Recovery

- i. Cost recovery in the irrigation sector is studied by estimation of the cost recovery index and benefit recovery index. Repayment cost and the O & M cost estimated by farm budget analysis would be the subjects for cost recovery analysis.
- ii. Cost recovery in industrial water sector is studied through estimation of the unit cost of raw water. The costs of Si Yat dam and Diversion dam are allocated to three sectors of agriculture, industry water and drinking water. The costs allocated to industrial water sector is used to estimate the unit cost of raw water.
- iii. Cost recovery in drinking water sector is studied through estimation of the affordable water charge.

3) Joint Cost Allocation

In order to evaluate an economy of the irrigation project and the cost recovery for industry and drinking water sectors, the costs of common facilities such as Bang Pakong diversion dam and Khlong Si Yat storage dam have to be allocated to each sector.

12-3. Identification of Project Benefit

12-3-1. Tangible Benefit

Agricultural Sector

- 1) Tangible benefits of agricultural projects are generated from an increased value of production of crops. An increased value is available through increase in crop yield and expansion of cropping intensity.

In order to raise productivity of crops, quantity of seed, fertilizer and agro-chemicals will be increased and intensive labors would be required. As the cropping acreage for the dry season is expanded through supply of irrigation water, the busy season for crop operation will be fixed as November and December. Hence, the system of mechanization shall be improved from the present system by which operation hours of machines for transplanted paddy occupy by 89% by small tractors owned, 8% of small tractors hired and 2% of large tractor hired.

2) Economic crop budget per ha is estimated as shown in the tables of Appendix. Table I-3-31 to I-3-49. Financial and economic prices of commodities or labor are applied to crop budget analysis.

As regards crop budget without the project, quantity of seeds, fertilizers, agro-chemicals and fuel and labor days and machine operation hours/cost are estimated based on the socio-agro economic survey conducted by RID, 1989. Labor days in the financial phase are counted on hired labor days and the economic phase total labor days.

3) Operating costs of large size machines with and without project are studied on the both phase of financial and economic view as shown in the Appendix. The operating cost items for agricultural large size machineries are categorized by fixed cost and variable cost. Fixed cost consists of depreciation, repair, interest, tax, insurance and car shed. Variable cost consists of wages of operators, fuel, and electric charge. Depreciation cost is not treated as a cost in the discounted cash flow analysis. Interest and tax are not counted in the economic operating cost. Financial and economic operating costs per hour are estimated. Financial and economic operating cost per hectare are estimated by crop. The latter is applied to crop budget.

4) Economic crop budget is studied on the year of 1995 and 2000. Application volumes of fertilizers per ha in the year of 1995 are estimated in considering the correlation curve studied on paddy yield and fertilizer volume which are sourced from the socio-agro economic survey, RID, 1989. This curve is shown in Appendix. FIG. I-3-3.

5) Annual economic value of crops, fruit trees lost by construction of Si Yat dam and diversion dam are counted as lost value in the benefit flow during project life.

The benefits generated from arable land developed in the resettlement project area are counted as the incremental benefit in the benefit flow.

6) Fresh water fish pond of 1,400 ha in surface areas is located in the existing Tha Lat area and Bang Pakong Expansion area. Cycle of fish culture

will be improved from one cycles to two cycle after completion of the project. The fishery benefit is counted in the benefit flow.

7) The water balance tentative Phase-I is estimated excluding the water quantity to be supplemented from the Si Yat dam. Hence, cropping intensity for dry season will be reduced from 50 percent to 30 percent.

8) Economic incremental net production value is shown in the following table.

TABLE 12-1 ECONOMIC INCREMENTAL NET PRODUCTION VALUE

Unit : Million Baht

Phase	Project Year	Agriculture			Fishery NPV	Total NPV
		With Project	Without Project	Incremental NPV		
Overall	1995	9.2	12.9	- 3.7	0.6	- 3.1
	1996	267.0	111.6	155.4	6.9	162.3
	1997	379.4	146.4	233.0	11.5	244.5
	1998	751.6	178.3	573.3	14.3	587.6
	1999	801.8	179.9	621.9	17.7	639.6
	2000	839.7	179.9	659.8	17.7	677.5
	2005	909.5	179.9	729.7	17.7	747.4
	2009	1,092.3	179.9	912.4	17.7	930.1
Phase-I	1996	219.7	84.2	135.5	4.0	139.5
	1997	287.7	86.6	201.1	5.3	206.4
	1998	504.0	102.1	401.9	5.3	407.2
	1999	515.7	103.5	412.2	5.3	417.5
	2000	524.3	103.5	420.8	5.3	426.1
	2005	544.1	103.5	440.6	5.3	445.9
	2009	544.1	103.5	440.6	5.3	445.9
Phase-II	1995	9.2	12.9	- 3.7	0.6	- 3.1
	1996	47.3	27.4	19.9	2.9	22.8
	1997	91.7	59.8	31.9	6.2	38.1
	1998	247.6	76.2	171.4	9.0	180.4
	1999	286.1	76.4	209.7	12.4	222.1
	2000	315.4	76.4	239.0	12.4	251.4
	2005	365.5	76.4	289.1	12.4	301.5
	2009	548.2	76.4	471.8	12.4	484.2

**TABLE 12-2 ECONOMIC INCREMENTAL NET PRODUCTION VALUE
FOR TENTATIVE PHASE-I**

Unit: Million Baht

Project Year	Agriculture			Fishery NPV	Total NPV
	With Project	Without Project	Incremental NPV		
1996	209.3	84.2	125.1	4.0	129.1
1997	275.0	84.6	190.4	5.3	195.7
1998	489.8	102.1	387.7	5.3	393.0
1999	501.6	103.5	398.1	5.3	403.4
2000	510.8	103.5	407.3	5.3	412.6
2001	519.3	103.5	415.8	5.3	421.1
2002	523.9	103.5	420.4	5.3	425.7
2003	526.4	103.5	422.9	5.3	428.2
2004	526.4	103.5	422.9	5.3	428.2

Industrial and Domestic Water Sectors

1) Benefit generated from the industrial and domestic water sectors are tangible through an estimate of water charge to be collectible from the users.

Items of capital costs related to the industrial and domestic water sectors are shown the following table. Capital costs of other facilities excluding those on diversion dam and Si Yat dam are not available. Hence, water charges must be estimated based on the unit price of raw water.

Major facilities of industrial and domestic water supply systems consist of the following components.

Industry Water Supply	Domestic Water Supply
- Water resources facility	- Water resources facility
- Pumping station	- Pumping station
- Conduction pipeline	- Filtration plant
- Receiving reservoir	- Transmission pipeline
- Respective treatment plants	- Receiving reservoir
- Distribution system	- Distribution systems

2) The method of estimate on the unit price of raw water based on the Japan Industrial Water Association is shown as follows.

Unit price of raw water per cu.m of collectible supply water volume

Unit price of raw water per cu.m of collectible supply water volume

$$= \frac{\text{Dam cost} \times (1 + 9.4 \times \text{interest} \times \text{construction period}) \times (\text{depreciation ratio} + \text{interest}) + \text{O \& M cost}}{\text{Annual collectible supply water volume}}$$

- i. Interest: 13% (commercial bank in Thailand)
- ii. Construction period : Diversion Dam 4 years
Si Yat Dam 5 years
- iii. Operation & maintenance cost:

Construction cost \times 0.5%
- iv. Depreciation ratio : Si Yat Dam $1/80 = 0.0125$
Diversion Dam $1/50 = 0.02$
- v. Annual collectible supply water volume

Industrial water:

$$\text{Annual intake water volume} \times 0.93 \times 1.0$$

(0.93 ... collectible ratio)

Domestic water:

$$\text{Annual intake water volume} \times 0.93 \times 0.75$$

(0.93 ... water supplied from purification plant/intake water from dam 0.75 ... collectible ratio)

3) Annual intake water volume are estimated as follows.

Item	Diversion Dam	Si Yat Dam	Total
Industry	100 MCM	70 MCM	170 MCM
Domestic	20	15	35
Total	120	85	205

4) Dam costs allocated to industrial and domestic water sector are shown in Appendix Table I-3-93.

- Project Cost -

Unit: million Baht

Item	Diversion Dam		Si Yat Dam	
	Financial	Economic	Financial	Economic
Dam cost which:	2,283	1,916	1,514	1,241
Agriculture	1,438	1,207	954	782
Industry & domestic	845	709	560	459

Note: Cost items are construction, compensation, engineering services, administration and physical contingency.

- 5) The unit price of raw water per cu.m of collectible supply water volume is estimated as follows. (refer to Appendix Table I-3-95)

- Price of Raw Water -

Unit: Baht/CM

Item	Diversion Dam		Si Yat Dam	
	Financial	Economic	Financial	Economic
Industrial water	1.40	1.18	1.32	1.08
Domestic water	1.97	1.61	1.68	1.38

- 6) The demands of water in the industrial and domestic water sectors would be satisfied from 1996 by Diversion Dam and from 1998 Si Yat Dam. Annual demand of water are assumed to reach the target of intake water volume by 2000 for Diversion Dam and by 2002 for Si Yat Dam. Annual demand of water is considered as annual intake water. Annual intake water volume is converted to annual collectible supply water volume as described above (refer to Appendix Table I-3-96 and I-3-97).

- 7) The incremental benefit is estimated by multiplying collectible water by year by water charge or price of raw water mentioned above. It is shown in the next table.

TABLE 12-3 INCREMENTAL BENEFIT TO BE EXPECTED FROM INDUSTRIAL AND DOMESTIC SECTORS

Unit: Million Baht

Item	1996	1997	1998	1999	2000	2001	2002
Phase-I (Diversion)							
Industry Collectible Water (MCM)	46.50	55.80	65.10	74.40	93.00	93.00	93.00
Water charge (Baht/cm)	1.18	1.18	1.18	1.18	1.18	1.18	1.18
Benefit (Milli.Baht)	54.87	65.84	76.82	87.79	109.74	109.74	109.74
Domestic Collectible water (MCM)	2.79	5.54	8.37	11.16	13.95	13.95	13.95
Water charge (Baht/cm)	1.61	1.16	1.61	1.61	1.61	1.61	1.61
Benefit (Milli.Baht)	4.49	8.98	13.48	17.97	22.46	22.46	22.46
Subtotal Benefit (Milli.Baht)	59.36	74.82	90.30	105.76	132.20	132.20	132.20
Phase-II (Si Yat Dam)							
Industry Collectible Water (MCM)	-	-	32.55	39.06	45.57	52.08	65.10
Water charge (Baht/cm)	-	-	1.08	1.08	1.08	1.08	1.08
Benefit (Milli.Baht)	-	-	35.15	42.18	49.22	56.25	70.31
Domestic Collectible water (MCM)	-	-	2.09	4.19	6.28	8.37	10.46
Water charge (Baht/cm)	-	-	1.38	1.38	1.38	1.38	1.38
Benefit (Milli.Baht)	-	-	2.88	5.78	8.67	11.55	14.43
Subtotal Benefit (Milli.Baht)	-	-	38.03	47.96	57.89	67.80	84.74
Total benefit (Milli.Baht)	59.36	74.82	128.33	153.72	190.09	200.0	216.94

All Sectors

The incremental benefits from all sectors, that is, agricultural, industrial and domestic waters are estimated in the following table.

TABLE 12-4 INCREMENTAL BENEFITS FROM ALL SECTORS

Unit : Million Baht

Project Year	Agricultural Water (Overall)	Industrial and Domestic Water	Total
1995	- 3.1	-	- 3.1
1996	162.3	59.4	221.7
1997	244.5	74.8	319.3
1998	587.6	128.3	715.9
1999	639.6	153.7	793.3
2000	677.5	190.1	867.6
2001	675.3	200.0	875.3
2002	683.0	216.9	899.9
2003	690.0	216.9	906.9
2004	709.9	216.9	926.8
2005	747.4	216.9	964.3
2006	804.2	216.9	1,021.1
2007	862.2	216.9	1,079.1
2008	904.1	216.9	1,121.0
2009	930.1	216.9	1,147.0
2010	930.1	216.9	1,147.0

12-3-2. Intangible Benefit

In addition to the tangible benefit for agriculture and fishery, various intangible benefits and socio-economic impacts are expected from implementation of the project comprised by agricultural industrial and drinking water supply sectors.

The major intangible benefit is described as follows.

1) Creation of New Job Opportunities

The project implementation needs a great deal of unskilled by labor during the construction period. Unskilled labor will be required about 500 thousand man-days per annum for construction of facilities during eight years. These man-days are equivalent to 33 million Baht worth of labor income per annum. Enlargement of crop acreage for dry season after completion of the project would require much hired labor.

Labor demand for crop husbandry would be increased from two million man-days per year to 5.4 million per year. Even though the family labor can serve much more days, much rural labor will be required. When about 30% of the total requirement is assumed to be hired, such labor income of about 107 million Baht is increased.

Supply of industrial and drinking water will promote the development of Bang Pakong and Plaeng Yao industrial estates. Consequently, creation of new job opportunities will be inscrutable.

2) Improvement of Local Transportation

Construction of the operation and maintenance roads is proposed along the Bang Pakong left main canal and Si Yat main canal. These roads will play an important role as the by-pass of the national road Root No.315 and the provincial road running along the left side of Tha Lat river, respectively.

The existing rural road passing through the proposed site of Bang Pakong diversion dam will be improved as the access road. After completion of the dam, this access road will be extended to south and cross the Bang Pakong river and be connected with the national road Root No.304. This new road will contribute not only to betterment of marketability of mango but also to inter-regional accessibility and communication. Especially a mass transportation of fresh fruits will be developed after conversion from navigation to overland transportation.

3) Improvement of Sanitary Conditions

The source of drinking water for the inhabitants in existing Bang Pakong area is the rain water stored. Public wells are not available due to the contents of acidity in subterranean water. Water for washing depends on creek fresh water.

After completion of Bang Pakong diversion dam, the drinking water supply will be available in the rural area mentioned above. Consequently, the sanitary conditions will be rapidly improved.

4) Improvement of Water Front Environment

Water quality in the downstream of Tha Lat irrigation canal has been become dirty because of increase in population in the rural area. In particular, dirtiness of the water cannot be cleared during dry season due to shortage of maintenance water of canal.

Such pollution of the canal water during dry season will be improved by supply of irrigation water to main canal after completion of the project.

12-4. Economic Analysis

12-4-1. Economic Project Cost

1) Capital Cost

The project cost consists of the direct project cost and the indirect project cost.

The direct project cost covers (1) preparatory work, (2) construction for storage dam, diversion dam, diversion weir, pumping station, irrigation system and drainage system (3) land acquisition, compensation and resettlement (4) procurement of O/M equipment (5) administration expenses, (6) expenses for engineering services, (7) physical contingencies and (8) price contingencies. All these costs are estimated on a financial basis as shown in Table 11-1.

In order to estimate the economic cost for agricultural sector, financial cost for Si Yat storage dam and diversion dam are allocated by 63% of agriculture sector and 37% of industry and drinking water sector.

The financial costs are converted into the economic costs by applying the conversion factor by cost component (CCF). (Ref. to Appendix Table I-3-58 to I-3-60).

TABLE 12-5 ECONOMIC PROJECT COST FOR AGRICULTURAL SECTOR

Unit: Million Baht

Component	Financial Cost			CCF	Economic Cost		
	Phase-I	Phase-II	Overall		Phase-I	Phase-II	Overall
A. Direct Project Cost							
1. Preparatory Work	20	26	46	0.900	18	23	41
2. Construction Cost	1,542	1,548	3,090	- 1/	2,321	1,291	2,613
3. Land Acquisition/Resettlement	375	680	1,055	0.920	68	418	486
4. O & M Equipment	11	11	22	0.968	11	11	22
5. Survey and Investigation	24	15	39	0.920	22	13	35
6. Administration Cost	106	130	236	0.920	98	120	218
7. Engineering Service	216	194	410	0.884	190	171	361
8. Physical Contingency	229	260	489	-	172	205	377
Total (1 - 8)	2,523	2,864	5,387	-	1,900	2,253	4,153
B. Indirect Project Cost							
1. Construction Cost	220	452	672	0.783	172	354	526
2. Engineering Cost	26	54	80	0.884	23	54	77
3. Physical Contingency	25	50	75	-	20	41	61
Total (1 - 3)	271	556	827	-	215	449	664
C. Grand Total (Agriculture)	2,794	3,420	6,214	-	2,115	2,702	4,817

Note : 1/ Conversion factor for construction cost is as follows.

Si Yat dam 0.850, Diversion dam 0.868, Diversion weir 0.821.

Pumping station 0.861, Irrigation system Phase-I 0.819, Phase-II 0.823, Drainage system 0.826.

The economic costs for all sectors are shown in Appendix Table I-3-60-1.

The financial costs for land acquisition, compensation and resettlement are adjusted to economic values by the following procedures. (Ref. to Appendix Table I-3-61).

Compensation costs for land and tree crop in the Si Yat reservoir area and Bang Pakong diversion dam site are adjusted to zero in economic cost.

Land acquisition cost for the irrigation canal sites is adjusted to zero by distance of canal running arable land. Financial resettlement cost is adjusted to economic value.

Price contingencies are excluded from the economic project cost.

2) The Annual Operation and Maintenance Cost (O & M Cost)

Annual operation and maintenance costs comprise salaries and wages, fuel and repair of equipment, material supplies and repair cost, pump operation cost and general expenditure. Financial O & M cost of 38.8 million Baht does not include the depreciation cost of O & M equipment. This financial cost is converted into economic cost by using conversion factor of 0.9.

Unit: Million Baht

Phase	Financial	Economic
Phase-I	17.0	15.3
Phase-II	21.8	19.7
Overall	38.8	35.0

3) Replacement Cost

Pumps proposed in Phase-I project and Resettlement Plan of Phase-II are replaced by interval of twenty years.

Unit: Million Baht

Phase	Financial	Economic
Phase-I	170	153
Phase-II	0.08	0.07

12-4-2. Economic Internal Rate of Return (EIRR)

The economic internal rate of return for the agricultural sector and all sectors are calculated on the basis of the flows of economic benefits and costs mentioned above. EIRR by phases is calculated as follows.

<u>Agricultural Sector</u>	Phase I	14.0%	<u>All sector 12.2%</u>
	Phase II	9.7%	
	Overall	11.7%	
	Phase I (Tentative)	13.6%	

12-4-3. Sensitivity Analysis

The sensitivity analysis is the effective measures of testing for the riskiness of projects. The analysis for the agricultural sector is made for the following cases:

- Case-1: 10% increase in project cost due to unforeseen able geological and topographical conditions and unexpected increase of material costs.
- Case-2: 10% decrease in project benefit due to unexpected decrease in prices of commodities and in crop yield.
- Case-3: Two years overrun of full-development period of project benefit.
- Case-4: Two years overrun of construction period.

The EIRR of these four cases are estimated as follows.

- EIRR (%) for Agricultural sector -

Case	Overall	Phase-I	Phase-II
Original	11.7	14.0	9.7
Case-1	10.8	13.0	9.0
Case-2	10.7	12.9	8.9
Case-3	11.1	13.3	9.4
Case-4	10.8	12.7	9.2

12-5. Financial Analysis

12-5-1. Farm Budget Analysis

The farm budget analysis is made in order to evaluate the Project from the financial aspect of the beneficiaries. Typical farms are represented by three farms with cropped land in the sub-project area, that is, existing Bang Pakong area, existing Tha Lat area and Tha Lat expansion area. The present farm economy in these sub-project areas were surveyed by RID, November to December 1989. Net farm income with and without-project is estimated as shown in the following table.

The financial project costs of 8,803 million baht are composed with the direct project cost of 7,778 million Baht and the indirect project cost of 1,025 million Baht. The former will be disbursed by the Government. While the latter will be unavoidably borne by other agencies or beneficiaries. In this study, the indirect cost, that is, on-farm works cost is assumed to be borne by the beneficiaries. They will borrow the capital from the BAAC's long term loans.

The Government will bear the operation and maintenance costs of facilities constructed through disbursement of the direct project cost.

However, the beneficiaries will pay the operation and maintenance cost of on-farm facilities in the water charge.

The annual repayment cost and operation and maintenance cost are sourced from incremental net farm income. Payable cost or payment capacity is estimated as incremental net farm income multiplied by marginal saving propensity of 40%.

The value to be borne by the average farmers in existing Bang Pakong area and Tha Lat expansion area is payable enough with the full amount of repayment cost and operation and maintenance cost. Incremental net farm income in existing Tha Lat area is short to pay the full repayment cost because of less net farm income than those in other both two-project areas.

12-5-2. Cost Recovery

1) Irrigation Sector

Since the establishment of the Land Consolidation Act in 1974, the beneficiaries are asked to bear a portion of the project costs for the on-farm water supply and drainage facilities.

TABLE 12-6 FARM BUDGET ANALYSIS

Item	Unit	Existing Bang Pakong Average Farm		Existing Tha Lat Average Farm		Tha Lat Expansion Average Farm	
		W/O/P	W/P	W/O/P	W/P	W/O/P	W/P
Cultivated Land	rai	18	18	17	17	30.0	34.6
	ha	2.9	2.9	2.7	2.7	4.8	5.5
A. Gross Farm Income	Baht						(2003 yr)
Crop		34,679	145,799	18,049	70,041	35,909	126,607
Livestock		1,840	1,840	3,970	3,970	3,940	3,940
Total		36,519	147,639	22,019	74,011	39,849	130,547
B. Production Cost	Baht						
Crop		14,992	65,218	7,349	39,576	18,171	63,340
Livestock		874	874	2,603	2,603	725	725
Total		15,866	66,092	9,952	42,179	18,896	64,065
C. Net Farm Income	Baht	20,653	81,547	12,067	31,832	20,953	66,482
D. Incremental NFI	"		60,894		19,765		45,529
E. Payable Cost of	"		24,360		7,806		18,212
which : Repayment	"		10,254		7,525		17,640
O & M Cost (Water Charge)	"		302		281		572
F. Full Repayment Cost	"	3,536 × 2.9	= 10,254	3,856 × 2.7	= 10,411		3,856 × 5.5
							= 21,208

Note : 1. W/O/P ... without project, W/P ... with project

2. Average size of farm by sub-project area is estimated basing on the Socio-Economic Data in 1987, NSO. Difference of W/O/P and W/P in Tha Lat Expansion Area is orchard area reclaimed.

3. Gross farm income for Tha Lat Expansion Area are shown by two case in 2001 and 2003 because of maturity period of new mango.

4. Family labor cost is excluded.

5. Payable cost is estimated as follows. Increment net farm income × 0.4 (marginal saving propensity)

6. Repayment cost is estimated for on-farm work cost to be born by beneficiaries. Beneficiaries would borrow the BAAC's long term loans with simple interest of 11% and installment years of 20.

7. Operation and maintenance cost is assumed that beneficiaries bear a part of total O & M cost under condition of ratio of on-farm work costs to total project costs.

8. Full repayment cost is estimated on all on-farm work cost.

In this study, repayment cost and O & M cost estimated by farm budget analysis would be subjects for cost recovery analysis.

In determining the extent of cost recovery, cost recovery index is used for the project. This index is measured at the ratio of incremental water charge (O & M cost) and on-farm work costs paid by all project beneficiaries to incremental project construction and operation and maintenance costs.

Water charges and repayment cost of on-farm work costs are estimated based on the present values discounted at 10% in annual rate of interest over the 50 years of the project life.

The proposed water charges and repayment cost would result in a cost recovery index of around 10%.

This index is measured at the rate of incremental water charges and repayment cost by a typical farmer to incremental farm income accruing to farmer before paying water charges and repayment costs.

As incremental farm income is indicated in the previous farm budget analysis, the proposed water charges and repayment cost would result in a benefit recovery index as follows.

Existing Bang Pakong area ...	$(10,254 + 302) / 60,894 = 17\%$
Existing Tha Lat area	$(7,525 + 281) / 19,765 = 39\%$
Tha Lat Expansion area	$(21,208 + 572) / 137,945 = 16\%$

The project cost represent financial flows from the public sector, and then corresponds to taxes and other transfer payments. After completion of the project, the taxes to be levied will increase because of a plenty of incremental benefit. The tax to be levied in future will be contribute to cost recovery of this project.

The Government will receive indirectly some revenue from the project as rice export tax, rice premium and milling tax. These indirect incremental revenue will amount to about 55 million baht per annum. Such revenue should be considered in the cost recovery study.

2) Industrial Water Sector

Industrial water supply in the lower reaches of the Bang Pakong river basin is mainly made from urban water work facilities, irrigation canals and small ponds. The water supply in the dry season, however, does not meet the requirements of the beneficiaries in most of area.

In particular, some factories have faced the purchase of water from Bang Phra reservoir located in southern part of Muang Chonburi by water tankrollies with the price of 70 baht per cubic meter.

Common facility's costs of Si Yat dam and Diversion dam are allocated by each sector of irrigation water including fishery, industrial water and drinking water as described in the paragraph 12.5.3.

The financial unit prices of raw water for the industry and drinking are roughly estimated at 1.32 to 1.40 Baht and 1.68 to 1.97 Baht per cubic meter respectively, mentioned in the paragraph 12.3.1.

This unit price of raw water would be attractive water charge to the factories purchasing with the price of 70 Baht per cubic meter.

As dam cost is borne by the Government, the private enterprises will be able to recover the specific cost excluding dam cost.

The cost recovery through levy of water charge including dam cost is recommended.

3) Drinking water Sector

Cost recovery in the drinking water sector is studied by estimation of the affordable water charge.

It is well known that the upper limit of "the ability to pay a water charge" is four (4) to five (5) % of their income for a household in the developing countries.

The affordable water charge is estimated as follows.

- Affordable Water Charge -

Area	Net Farm Income W/P <u>1/</u> Baht	Monthly NFI <u>2/</u> Baht	Ability to Pay per Month <u>3/</u> Baht	Water Charge <u>4/</u> Baht/CM
1. Existing Bang Pakong Area	81,547	6,975	272	12.1
2. Existing Tha Lat Area	31,832	2,653	106	4.7
3. Tha Lat Expansion Are	66,482	5,540	222	9.9

Note: 1/ : based on Farm Budget Analysis

2/ : 1/ / 12 month

3/ : 2/ × 4%

4/ : 3/ / 22.5 CM

(5persons × 150 ℓ./day × 30 day = 22.5 CM)

The unit price of raw water for drinking water sector is estimated at 1.68 to 1.97 Baht per cubic meter. Hence, affordable water charge including the unit price of raw water is practical to the average size of farms in Existing Bang Pakong area and Tha Lat Expansion area.

The affordable water charge for the Existing Tha Lat area is very low. And according to the socio-agro economic survey conducted by RID, the average size of farm earn the off-farms income of about 26,000 Baht. When the off-farm income is added to net farm income, the affordable water charge is improved by about 8.5 Baht/cu.m.

As a conclusion, the cost recovery for the drinking water sector is considered possible through levy of water charge of around eight to 10 Baht per cubic meter.

12-5-3. Joint Cost Allocation

Bang Pakong Diversion dam and Khlong Si Yat Storage dam will be commonly used by sectors of irrigation, industry water and drinking water.

In this project, the cost allocation is categorized by two types. One type is an individual allocation of cost of each dam, and another type is comprehensive allocation of the totalized cost of the both dams. In this study, considering the following hydrological items, the comprehensive cost allocation method is adoptable.

The reservoir volume of Bang Pakong diversion dam is only 30 MCM, but the stored water is rotated in high efficiency through supply from Si Yat dam, Rabom dam and runoff from upper stream of the Bang Pakong river. Hence, the water users to be directly supplied through Bang Pakong diversion dam should also participate in allocation of Si Yat dam cost.

Joint cost allocation is studied on two methods . The method used for the first step is that is known as the "separable cost - alternative justifiable expenditure". The method used for the second step is the water quantity allocation method.

Adoptable cost allocation method has to be satisfied by both with the factors, that is, financial justification for irrigation sector and reasonable cost of raw water for industry and drinking water.

Figures estimated through adoption of water quantity allocation method, that is, 63% of irrigation and 37% of industry and drinking water, are

reasonable for the both factors mentioned above. These figures are used for allocated of costs of the both dams for economic evaluation of irrigation sector.

12-6. Project Justification

Economic internal rate of return (EIRR) for all sectors was estimated at 12.2 percent.

EIRR for overall basin project in the agricultural sector was estimated at 11.7 percent.

It was reported that the latest prime rate of loan interest is 15 percent at the minimum and the deposit loan rate is 12.5 to 13 percent. When the marginal productivity of capital is considered to be approximately the deposit loan rate the economy of all sector projects is rightly justifiable. The cost-benefit ratio for the agricultural sector will be considered viable from the national economic point of view.

**CHAPTER 13. ENVIRONMENTAL IMPACT
EVALUATION**

CHAPTER 13. ENVIRONMENTAL IMPACT EVALUATION

13-1. Introduction

Dam and irrigation projects generally give significant effect in alternation of the environmental resources. In this regards, the National Environmental Board (NEB) worked out the "Guideline for Preparation of Environmental Impact Evaluations" in 1979 with a view to conserving the environmental resources in the national land. According to this guideline, all agencies that propose to undertake construction of any projects are requested by NEB to prepare an appropriate "Environmental Impact Statement (EIS)" and to submit it to NEB for review and further actions.

The detailed EIS is required if the main features of the proposed project exceed in their values the following guideline:

- Effective storage : 100 MCM
- Reservoir area : 15 km²
- Irrigation area : 80,000 rai (12,800 ha)

The proposed Tha Lat River Basin Development Project has been divided into two phases in view of the project implementation, and the major figures of the both phases are larger than those of the above guideline in scale and therefore the detailed EIS will be required.

Main Features of Tha Lat River Basin Development Project

	Phase-I	Phase-II	Overall Development
Effective Storage (MCM)	30	300	330
Reservoir Area (km ²)	10	45.5	55.5
Irrigation Area (rai)	14,700	30,240	43,540

The environmental study comprises manifold items of environmental impact evaluations. They are primarily classified into the following four categories:

1) Physical Resources

- Surface water hydrology
- Surface water quality
- Groundwater hydrology
- Groundwater quality

- Soils
- Geology and seismology
- Erosion and sedimentation
- Climate

2) Ecological Resources

- Fisheries
- Aquatic biology
- Wildlife
- Forests

3) Human Use Values

- Agriculture and Irrigation
- Aquaculture
- Water Supplies
- Navigation
- Reclamation
- Power
- Flood Control
- Dedicated area Use
- Industry
- Agro-industry
- Mineral Development
- Highway and Railway
- Land Use

4) Quality of Life

- Socio-economic values
- Resettlement
- Cultural and Historical values
- Anesthetic Values
- Archeological Values
- Public Health
- Nutrition

A full-scale environmental study covering the above items with appropriate analysis and recommendations in sufficient details is required for the large scale dam/irrigation projects like the subject Project for preparation of the detailed EIS. Difficulties are, however, involved in making such the full-scale environmental study in sufficient detail within the limited time of study period under the present framework of the feasibility study. Preliminary studies are only carried out at the current stage of the study for the purpose of pointing out the present environmental problems and constraints and the

anticipated alternation in environmental resources, either positive or negative, will be caused by the project implementation.

The study covers the drainage area of 2,493 km², including the entire Tha Lat river basin and a part of direct catchment of the lower Bang Pakong river, may receive more or less environmental impacts by the development of the dam, diversion and irrigation and other water supply systems of the project.

13-2. Preliminary Environmental Impact Study for Phase-I Project

13-2-1. Physical Resources

1) Surface Water Hydrology

The Phase I of the Project will cover 12,700 ha of the existing and 2,000 ha of the new expansion areas of Bang Pakong Left Bank. Supplemented with water released from storage dams under construction or to be constructed upstream of the Tha Lat river, the Project aims to divert the Bang Pakong river water multipurposely for irrigation, industry, and drinking as well as for brackish and freshwater fisheries through the proposed Bang Pakong diversion dam, pumping station, irrigation main canal and other necessary facilities.

The Bang Pakong river runoff from the upstream basin is characterized by long low flow in the months from December to May. The wet season flow occurs from June through November with the highest flow in September. Generally the wet season flow accumulates to about 80 to 90% of the total annual flow. Flow regime of Bang Pakong river at the proposed diversion damsite before and after Project, in terms of 10-day flow volume in MCM, has been summarized for the specific years of 1983, 1972 and 1979, which represent a plenty year, ordinary year and doughty year respectively, as shown in Table 13-1. In the table, river flow before Project includes neither the flow released from the upstream dams (Raborn and Si Yat) nor the excess runoff from the catchment of the Tha Lat river, therefore it can not be directly compared with that after Project.

However, at the operation phase of the diversion, there will be no impact on flow discharges and patterns during wet season because the gate will be fully opened to release flow natural. On the contrary during dry season, the river flow will much decrease due to water diversion for various water supply purposes. Occurrence of flash flood may not induce back water upstream if an appropriate rule of the gate operation is introduced accompanied with establishment of the basin monitoring systems.

Presently, there are no usage of the Bang Pakong river water during dry season except shrimp culture because of salinity problem. After closure of

TABLE 13-1 ALTERNATION OF HYDROLOGIC REGIME AT DIVERSION DAMSITE

Month	Plenty Year (1983)			Ordinary Year (1972)			Droughty Year (1979)		
	Before	After	Balance	Before	After	Balance	Before	After	Balance
April	0.82	2.15	1.33	57.81	53.49	▲ 4.32	10.40	2.15	▲ 8.25
	0.89	2.15	1.26	65.74	64.41	▲ 1.33	41.94	31.23	▲ 10.71
	4.51	2.15	▲ 2.36	39.70	37.44	▲ 2.26	38.64	32.50	▲ 6.14
May	59.89	51.11	▲ 8.78	19.50	8.27	▲ 11.23	56.28	56.69	0.41
	42.80	31.54	▲ 11.26	30.64	18.62	▲ 12.02	138.51	139.69	1.18
June	61.68	56.91	▲ 4.77	23.60	10.46	▲ 13.14	164.60	159.98	▲ 4.62
	187.80	193.84	6.04	134.96	140.85	5.89	138.35	142.42	4.07
	89.44	94.46	5.02	99.50	104.23	4.73	135.61	147.67	12.06
July	72.17	75.79	3.62	147.09	152.31	5.22	162.00	171.21	9.21
	11.20	9.97	▲ 1.23	197.15	201.79	4.64	774.45	795.56	21.11
August	313.31	319.31	6.00	163.47	162.32	1.15	254.64	274.00	19.36
	183.49	193.54	10.05	193.07	187.72	▲ 5.35	352.69	380.76	28.07
	635.93	669.04	33.11	266.35	264.10	▲ 2.25	493.69	516.39	22.70
September	881.35	926.01	44.66	331.84	322.76	▲ 9.08	219.18	210.50	▲ 8.68
	497.31	508.45	11.14	148.98	139.81	▲ 9.17	123.96	120.08	▲ 3.88
October	247.84	282.37	34.53	871.36	904.55	33.19	23.23	18.62	▲ 4.61
	120.29	136.48	16.19	777.01	839.89	62.88	79.70	127.02	47.32
November	636.49	674.52	38.03	311.17	373.49	62.32	806.58	837.55	30.97
	928.97	981.53	52.56	473.68	505.09	26.41	250.09	304.66	54.57
December	1,142.57	1,248.21	105.64	297.68	316.73	19.05	20.16	16.89	▲ 3.27
	132.76	220.21	87.45	83.34	77.11	▲ 6.23	26.00	14.49	▲ 11.51
January	86.15	98.54	12.39	106.90	105.70	▲ 1.20	7.13	2.15	▲ 4.98
	117.00	133.89	16.89	187.41	191.27	3.86	7.13	3.20	▲ 3.93
February	7.13	2.99	▲ 4.14	135.15	136.73	1.58	7.13	2.15	▲ 4.98
	30.04	16.24	▲ 13.80	119.12	107.48	▲ 11.64	30.06	16.17	▲ 13.89
March	9.82	2.15	▲ 7.67	85.47	71.87	▲ 13.60	10.18	2.15	▲ 8.03
	24.25	9.35	▲ 14.90	27.66	12.47	▲ 15.19	3.69	2.37	▲ 1.32
Annum	41.41	26.04	▲ 15.37	29.98	14.59	▲ 15.39	8.09	2.15	▲ 5.94
	11.44	2.15	▲ 9.29	9.26	2.15	▲ 7.11	2.61	2.15	▲ 0.46
Annum	16.71	2.58	▲ 14.13	5.45	2.37	▲ 3.08	0.88	2.37	1.49
	3.55	2.15	▲ 1.40	2.99	2.15	▲ 0.84	1.48	2.15	0.67
Annum	16.94	4.94	▲ 12.00	2.39	2.15	▲ 0.24	3.81	2.15	▲ 1.66
	47.70	35.08	▲ 12.62	4.87	1.94	▲ 2.93	2.42	1.72	▲ 0.70
Annum	28.07	12.31	▲ 15.76	2.53	2.15	▲ 0.38	1.91	2.15	0.24
	11.21	2.15	▲ 9.06	7.49	2.15	▲ 5.34	10.30	2.15	▲ 8.15
Annum	32.02	19.24	▲ 12.78	32.69	22.00	▲ 10.69	11.17	2.37	▲ 8.80
	6,735.0	7,049.6	314.6	5,498.0	5,562.6	64.6	4,418.7	4,477.7	129.0

the river by the diversion dam, the retained fresh water will be used for various purposes both for private and public sectors locating in the vicinity of the river.

Downstream of the diversion site, the water will become more saline than that at present achieved because a small amount of freshwater will only be released in dry season. The water of high salinity of by more than 25 ppt will affect growth rate of shrimp. Provision of freshwater to dilute water salinity within the limit should be taken into consideration.

2) Surface Water Quality

The latest data on physico-chemical properties of Bang Pakong river are available from NEB, published in September 1988. The Study Team also carried out water quality survey in the river to extend the NEB information during the period from December 1989 until June 1990.

The survey of residual pesticides in Bang Pakong river by NEB during 1985 - 1987 revealed that some pesticides including DDT, BHC, dieldrin, aldrin, and heptachlor measured at stations upstream of the proposed diversion site showed a value slightly exceeding the limit set up by NEB. The high value of pesticides was detected on November which is the month of releasing return flow from paddy field. The results of pesticides survey by the Study on January and April, 1990 also revealed that in general their values were slightly higher than the standard. The Station 4 (downstream of diversion site) showed poor water quality with values of all pesticides detected exceeding NEB standard. For stations located upstream, the values of aldrin in January and BHC in April only were appreciably larger than the standard.

For NEB data again, the values of DO, BOD and Coliform bacteria analyzed during 1981 - 1987 show that the Bang Pakong river has been much contaminated. The contamination increase from just downstream of Amphoe Bang Khla through the river toward the Gulf, with the severe situation around Chachoengsao provincial seat. The major contamination sources encouraging low value of DO and high BOD and coliform bacteria are mainly domestic effluent water from Bang Khla and Chachoengsao towns as well as effluent from swine farms.

DO values at the distance 0-80 km from the river mouth (Amphoe Bang Khla is around 80 km) is under NEB's water quality classification No.4 and the water under this classification should be specially treated before drinking or domestic use. Regarding the study results, DO values inspected at stations 3 and 4 (downstream of diversion) were higher than those at stations 1 and 2 (upstream of diversion). April and May are the period of low DO value at stations 3 and 4 whose water quality is regarded as Class No.4.

With respect to the value of BOD and Coliform bacteria, the similar pattern of concentration as DO is depicted, i.e., increased their value around

Bang Khla and much more on downstream. However, such value is still not so serious and causes this river section to be classified as water quality class No.3. The BOD value analyzed by the Study is rather conformable with NEB with the value of around 1 - 2 mg/lit. except those in March at stations 3 and 4 of which values are as high as more than 2 mg/lit.

The problem on heavy metals including Cu, Zn, Cd, Cr, Pb, Mn and Fe accumulating in the upstream water is not so serious yet because most of factories in Bang Pakong river basin are of agro-industry type. Monitoring of these heavy metals by NEB during 1983 - 1987 found that most of them still remained within the standard value. However, such metals as Cr and Fe show their value slightly higher than the standard in some years and at some sampling stations. The checking of those parameters by JICA indicates less significant difference and the most are still within the NEB standard level.

NH₃-N, MP₃-N and total phosphorus were detected in small amount by both NEB and JICA. Solid, hardness, alkalinity and chloride depend generally on seasonal sea water intrusion. The value at Station 1 is the lowest increasing at the sections downstream. Most of these concentrations are regarded as high level at all sampling stations during January and March.

Water contamination due to decomposed weeds is another matter for consideration. During the preparation period of rice harvesting, in July and November for wet and dry planting seasons respectively, the farmers will drain out water retained on their farmland to natural streams that further flows into Bang Pakong river. This polluted water by decomposed weed, grass and straw involving some floating materials will be accumulated behind the diversion dam.

Water contamination is expected to be more serious due to blockage of upstream flow. The major sources of pollutants include community discharge of Muang Chachoengsao and Bang Pakong, irrigation return flows, sewage from shrimp farm and effluent water from industry such as rice flour and plant in Amphoes Muang and Ban Pho, and squid processing plant in Amphoe Bang Pakong. This degraded water quality will cause some trouble on shrimp culture and estuarine fisheries.

During the period of construction, turbidity and suspended soils followed by siltation in downstream section will temporarily increase particularly in wet season. The considerable impacts of this degraded water quality will be on water supply system of Amphoe Chachoengsao (pumping through Khlong Tha Khai) and domestic use by villagers in the areas of both banks. If the construction is carried out in dry season, the effects will be on shrimp culture and estuary fisheries.

The above discussion on water contamination in Bang Pakong river will conclude preliminarily that the values of pesticides, DO, DOD and coliform bacteria were rather beyond the standard level of NEB. It is not due to the Project implementation, but is very important that the measures/programs for controlling the concentration within the allowable limit should be implemented as early as possible, otherwise the retained water by the diversion may become unsuitable for utilization as water supply. The possible measures at this moment may be as follows:

- Campaign to farmers to use less toxic pesticides
- To advise the farmers to plant rice with a variety of high resistant to pest and diseases
- Serious intention to be paid on controlling measures of effluent water from swine farm and industries
- To release retained water at the location below water surface
- Continuous monitoring of water quality after completion of the diversion

In this connection, the proposed Project envisages to consolidate drainage facilities to drain effluent water from swine farm and industries downstream of the diversion dam.

3) Soil Erosion

Nipa palm has been observed along the banks of Bang Pakong river and its tributaries. After the project implementation, the nipa palms growing may be impeded in some cases by salinity change, resulting in some impact on possible soil erosion on river banks after a long while. It is very important to monitor the growing situation carefully.

4) Groundwater

Water level upstream of the diversion dam is planned to be controlled within the range between (=) 1.5 m and (-) 1.5 m. The level below zero is, however, to be avoided whenever possible, since it would cause adverse flow of groundwater and in turn leakage of saline water would be resulted.

5) Sedimentation

In the upstream of the diversion dam, the riverbed will be elevated because of back sand at the edge of the reservoir during dry season. It is planned, however, that the gates are fully opened in wet season, during which sediment deposits are easily flashed out through the river channel into the area. Therefore, environmental impact by change of transportation mechanism of sediment is considered very little.

13-2-2. Ecological Resources

1) Aquatic Ecology

Retention of freshwater in the Bang Pakong river will induce significant changes in aquatic eco-systems. Study of existing ecological characteristics is considered to be important so that the ecological changes can be anticipated and mitigated as much as possible. The report on "Aquatic Ecological Studies of the Bang Pakong River and the Assessment of Impacts from Bang Pakong Thermal Power Plant, Phase 2" prepared by the National Inland Fisheries Institute in 1987 revealed that this river is still abundance of aquatic animals but have a trends of decreasing due to human activities.

Diversification and abundance of plankton in Bang Pakong river depended mainly on water salinity, tide, season and human activities. The river mouth is the area accumulating nutrients come from upstream watershed. These nutrients such as phosphate and nitrate are the major food for phytoplankton which is primary production of ecology, consequently, secondary production is zooplankton which is food of aquatic animal larvae. The Bang Pakong river is influenced by sea water intrusion, causing the interface zone between freshwater and sea water in the river. This limnetic boundary has 1-3 ppt of water salinity and more up and down according to tidal effect. The larvae and egg of aquatic animals touching this barrier are severely affected and some become death.

At the period of high salinity content in river water, zooplankton was found abundantly, particularly at the river mouth. This saline zooplankton decrease at the section upstream depending on water salinity, until they reach the limnetic oligohaline boundary, by then the occupant will be freshwater plankton.

At the river section influenced by sea water, Chrysophyta (yellow - green algae) is the dominant phylum of phytoplankton, having diatom as an important type. While at the section north of the confluence of Prachin and Nakhon Nayok rivers where the river becomes freshwater, Chlorophyta (green algae) is commonly observed. Regarding zooplankton, phylum Arthso-poda,

class crustacean of order copepoda is the most abundant in the lower part of the river, the economic types of zooplankton that are still abundant including Decapoda, shrimp larvae, mollusca larvae and fish egg. The fry of these planktons were appeared at different period due to their different spawning season, shrimp fry was found all year but commonly observed to migrate upstream in March. Fish fry normally appears the upper river section for growth in fresh or brackishwater during May and August. the abundance of zooplankton was inspected and evaluated by the August. The abundance of zooplankton was inspected and evaluated by the National Inland Fisheries Institutes in 1987, approximately 47 - 70% lower than the figure in 1982.

The aquatic ecology as discussed briefly above will change when the diversion dam has been implemented. Ecology of Bang Pakong river is very complicate and requires much more time for study in order that it's impact change can be minimized.

2) Fisheries

Latest information on fisheries in Bang Pakong river was surveyed by the National Inland Fisheries institute during March 1982 - 1983. As high as 106 species of fishes and aquatic animals including freshwater, brackishwater and marine species was observed with major economic species, respectively, of *Puntioplites protozysron*; *Macrobrachium rosenbergii*, *Penaeus monodon*; *Loligo sp.*, and *Lates calcalifer*; *Epinephelus sp.* These aquatic animals distribute and migrate up and down the river according to the changing pattern of salinity of water due to the intrusion of sea water from the Gulf. the total catch of fishes and other aquatic animals in the river by fishermen was estimated at 230 metric tons per year. The most economic species was the giant freshwater prawn with the average catch of about 23 metric tons per year, (See Table 13-2). More than 20 types of fishing gear were used by the fishermen in the river and the major type of fishing gear observed were set bag, drift net and set bag net.

Presently, such abundance of aquatic animals as well as fishing activities become considerably lower than the 1982 - 1983 survey, according to observation and interview with fishermen in field. The probable reasons of decreasing fisheries resources and amount of catch include: -

- Illegal use of fishing gears particularly scissor-net at the river mouth.
- Water contamination in the river particularly at the river mouth which is spawning ground of aquatic animals.

- High temperature of released water from Bang Pakong power plant which forced the fry of aquatic animals to migrate and grow upstream.
- The local villagers who can earn more income from other activities.

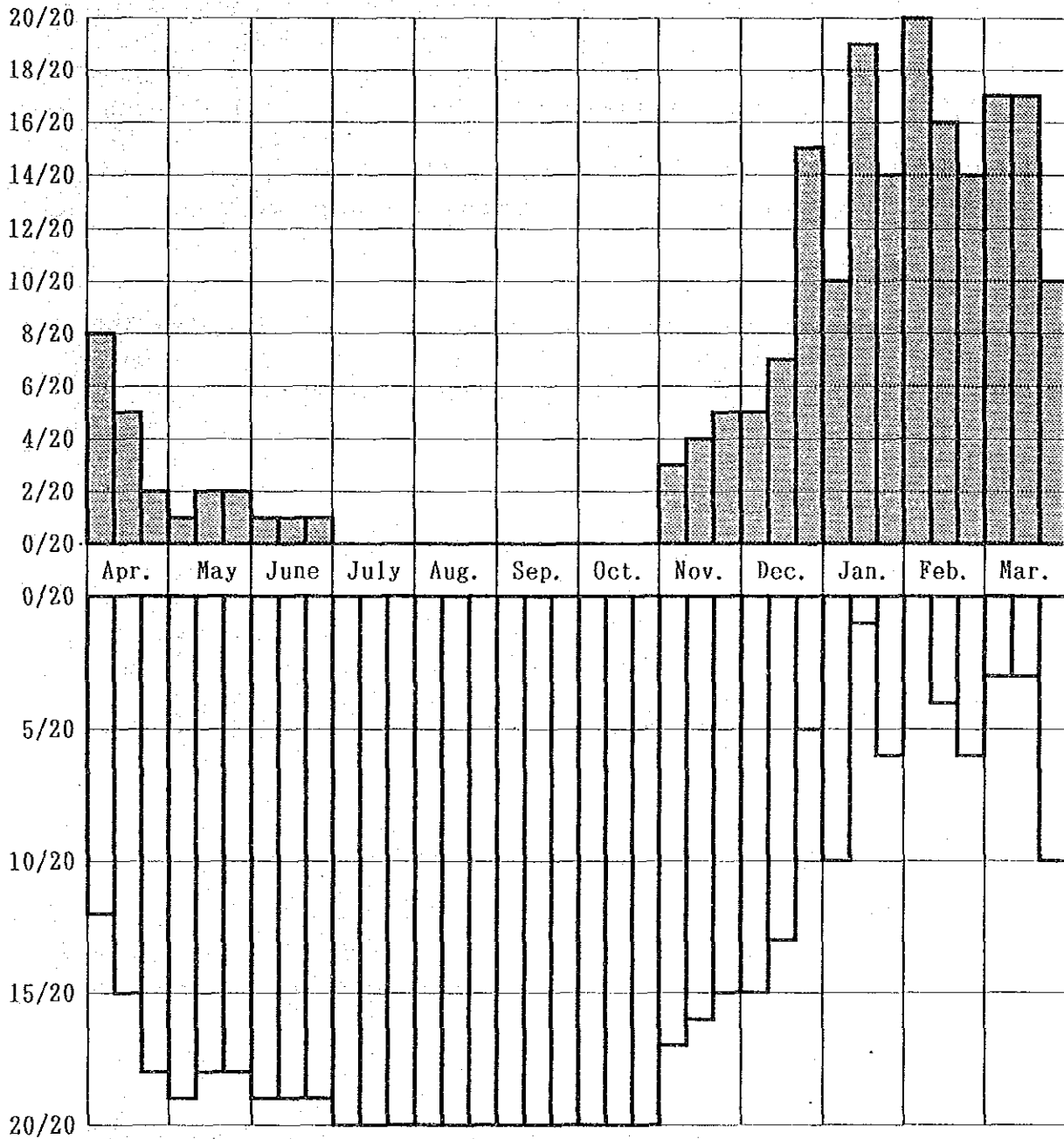
Table 13-2. Amount of Aquatic Animals Caught From Bang Pakong River, March 1982 - February 1983

Month	Caught by Fishermen	Amount of Caught Survey from Market (kg)			Total
		River	Pond	Giant Shrimp	
March 1982	9,877	21,360	16,430	1,500	39,290
April	29,311	2,174	16,410	2,709	21,293
May	39,776	31,015	5,250	4,185	40,450
June	67,220	20,589	9,810	3,699	34,098
July	24,857	18,924	10,890	540	30,354
August	7,933	1,692	19,200	76	20,969
September	901	22,485	17,280	204	39,969
October	5,608	20,091	1,950	2,220	24,261
November	4,714	90,042	-	-	90,042
December	3,088	91,821	2,835	2,490	97,146
January 1983	12,549	46,743	5,934	1,695	54,372
February	24,304	71,640	8,424	3,750	83,814
Total	230,183	438,576	114,413	23,068	576,057
Monthly Average	19,178	36,548	9,534	1,922	48,004

The construction of diversion dam will inevitably effect migratory of fry and adult of fishes and some aquatic animals. In Bang Pakong river, the spawning season of fishes is around April to July, and the fish fly migrate upstream to grow during May to August. the operation of the diversion as well as engineering facilities design such as provision of fish way should be taken into consideration.

In this regard, the proposed Project aims to release the minimum flow discharge at the diversion dam through out a year even during a critical dry period. As the minimum flow discharge, the river maintenance water of a 0.1 m³/sec/100 km² was employed as a guideline. The minimum discharge of 2.49 m³/sec or 2.15 MCM/10 days from the developed catchment of the Tha Lat river (2,493 km²) is thus guaranteed by the Project. Figure 13-1 illustrates the histogram showing the frequency of 10-days during which only the minimum discharges are released from the diversion dam. From the said figures, discharges exceeding the minimum are 80% ensured in April, 90% in May and June, and 100% guaranteed during the months July to October when the gates are kept full opened. This minimum discharge will spill over the regulating gate(s) with the water depth of 10 to 20 cm, through which fishes can proceed

FIGURE 13-1 SEASONAL FREQUENCY OF MINIMUM DISCHARGE AT DIVERSION DAM



Note: Frequency is given in number of years per 20 years.

over the gate upstream and downstream. The fishway construction will cost too high to afford facility of fishes and aquatic animals only in a dry season.

The shrimp growers downstream of the diversion dam will be fully supplied with freshwater by the Project, resulting in a great improvement of the present growing condition of shrimp. About 1,000 ha of freshwater fishpond located nearby the terminal end areas of the existing Tha Lat and proposed Bang Pakong irrigation main canal are also supplied with adequate volume of water by the Project, improving existing one cycle of fish culture per year into two cycles and in turn earning the benefit of 16 million baht and 17.7 million baht in terms of the financial value and economic value, respectively.

3) Nipa Palm

Presently, nipa is considered as one of economic tree crops among villagers located close to the river channels. The growing situation will therefore be monitored carefully after the project implementation.

13-2-3. Human Use Values

1) Water Supply/Irrigation

About 190 thousand of population can be served with drinking water allotted from the storage of the diversion dam. Since no groundwater is available in the vicinity due to acidity, this water supply to be achieved by the Project will contribute to a great extent to upgrading of sanitary standard among the local inhabitants.

Raw water to be distributed from the diversion dam to industrial sector will promote the establishment of industries in the area.

The proposed Project will provide about 19,320 ha of farmland in the existing and 2080 ha in the proposed expansion of Bang Pakong Left Bank area, accordingly raising the cropping intensity of the area from 100% up to 150%.

2) Navigation

Navigation in Bang Pakong river is mainly for passengers traveling between Muang Chachoengsao and Amphoe Bang Khla. Transport of goods at the proposed diversion site is rarely observed. If the road linking both the river banks by way of the diversion dam is provided, a ferry will not be necessary and the transportation to the other bank be improved very much. The transportation along the river, however, will be interfered by the diversion dam. Landing places for passenger boats at the site will therefore unavoidably

be needed to transfer the boats. The construction cost of the navigation lock is too expensive to offer convenience to the villagers.

The followings are information on passenger boats operating between Muang Chachoengsao and Amphoe Bang Khla.

Express Boat : There are 2 boats operating between Muang Chachoengsao and Bang Khla, 32 persons capacity

	Boat No.1	Boat No.2		Boat No.1	Boat No.2
6.30	Depart from BK		12.00		Arrive to BK
7.30	Arrive to MC		12.30	Arrive to MC	
8.00		Depart from BK	13.00		Depart from BK
8.30	Depart from MC		13.30	Depart from MC	
9.30		Arrive to MC	14.30		Arrive to MC
10.00	Arrive to BK		15.00	Arrive to BK	
10.30		Depart from MC	15.30		Depart from MC
11.00	Depart from BK		17.00		Arrive to BK

For Saturday and Sunday, there is only one boat operating during morning and evening periods without fixed schedule. The boat-fare is 10 baht per person.

Long-tail Motor Boat : About 10 boats operating between Chachoengsao and Wat Mai Bang Khla.

04.30 First trip departs from Wat Mai Bang Khla and the latters operate behind 0.5 hrs interval.

05.30 First trip departs from Muang Chachoengsao and the latters operate behind 0.5 hrs interval.

19.30 The last trip departs from Chachoengsao

The type of boat operate every day, with 10 baht/person boat-fare.

A new transportation to connect directly the both banks will be available through a bridge to be installed with the diversion dam. The present navigation will partially altered by inland transportation system, promoting (1) mobilization of population in the rural area, (2) mass transportation of fresh agricultural products and (3) accessibility to the remote markets.

13-2-4. Quality of Life Values

1) Socio-Economics

The project cost of 3,979 million baht will be invested in seven year 1991 to 1997. After compilation of the Project, benefits will be extended to 5,140 of farm households and 29,300 persons of population in agriculture sector and to about 190,000 of service population in water supply sector. Establishment of Bang Pakong Industrial estate will be promoted by supply of raw water from the diversion dam.

Development of infrastructure for agricultural production, industrial production and social life will effect important impacts in environmental situation in each sector.

As regards environment on production, expansion of cropping intensity owing to improvement of stable irrigation water supply, promotion of crop production to meet the trend of market prices, enlargement of labor market, expansion of commercial production to over-come high land price etc. are expected.

Environmental impacts on social life are represented by the upgrading sanitary standard expansion of job opportunity, increase in living costs because of urbanization of rural life, etc.

As for transportation, mobility of local inhabitants and mass marketability using the O & M road along the new main irrigation canal and new road passing through the diversion dam will become active.

2) Resettlement/Compensation

Assets to be compensated in Phase-I Project are land, fruit trees, structure lost by construction of diversion dam, pumping station and main irrigation canal, and dump site borrowed. Compensation cost is estimated at 375 million baht excluding physical and price contingencies.

Number of farm household to be removed due to construction of diversion dam is estimated at about 30 and arable and other lands at about 51 ha.

These farmers are almost fruits growers methods to remove these farm households are classified into two; (1) resettlement of orchard garden to the land reclaimed in Bang Pakong river (2) monetary compensation. The former will meet the difficulty on improvement of acid soil and the clayish foundation. Careful survey on farmer's attitude and intention has to be carried out by the Government.

13-3. Preliminary Environmental Impact Study for Phase II Project

13-3-1. Physical Resources

1) Surface Water Hydrology

Table 13-4 summarizes seasonal inflow and outflow into and from the upstream storage dams (Rabom and Si Yat) which would represent the flow regime of the river immediate downstream of the dams, before and after completion of the Project. From the said table it is quite clear that the major function of these dams is to store river runoff into the reservoirs during wet season and to release stored water for various purposes during dry season.

2) Water Quality

Water quality of the Si Yat river is within a suitable limit for domestic and irrigation uses. However, the Khlong Si yat reservoir have a character easy to form thermocline. The thermocline is usually formed during the transition period between cooler season and hotter season. Once the thermocline is formed in the reservoir, the dissolved oxygen will be reduced and water quality will become worse.

3) Sedimentation

In the dam plan, the sedimentation rate has been estimated at about 250 m³/km²/year in the reservoir as a safety measurement.

13-3-2. Ecological Resources

It is estimated that about 76% of the reservoir area of under 5,400 ha or 33,750 rai has been developed as arable land.

Forest land is classified into a dense forest a scattered forest, controlled by the Royal Forest department. In particular, a scattered forest is mixed with the fallow land and the land under cleaning. Hence, an accurate acreage of forest land is not obtainable from the topographic map in scale 10,000. The extent of land with forest, fallow land and land under claring is estimated at about 1,245 ha (7,786 rai).

According to the Royal Forest Department, the common kinds of trees are as follows:

TABLE 13-3 NUMBER OF DAYS WHICH RELEASE DISCHARGE INDICATED

Water Year	Number of Days			Frequency of Storage	
	<Q _{min}	=Q _{min}	>Q _{min}	<Full St.	=Full St.
1968	-	111	255	-	366
1969	-	79	286	-	365
1970	-	82	283	-	365
1971	-	131	234	-	365
1972	-	70	296	-	366
1973	-	163	202	-	365
1974	-	100	265	21	344
1975	-	140	225	20	345
1976	-	90	276	-	366
1977	-	72	293	-	365
1978	-	142	223	-	365
1979	-	143	222	-	365
1980	-	72	294	-	366
1981	-	81	284	-	365
1982	-	102	263	-	365
1983	-	70	295	-	365
1984	-	110	256	-	366
1985	-	92	273	-	365
1986	-	102	263	-	365
1987	-	162	303	-	365
Maximum	-	163	303	21	366
Minimum	-	62	202	-	344
Average	-	101	265	2	363

- Notes : 1) Minimum Discharge = Q_{min}
 $= 2,493 \text{ km}^2 \times 0.1 \text{ m}^3/\text{sec}/100 \text{ km}^2 = 2.493 \text{ m}^3/\text{sec} = 2.15 \text{ MCM}/10 \text{ days}$
- 2) Effective storage = 30 MCM between (+) 1.00m ~ (-) 1.00m.
 Diversion dam is controlled always full whenever storage is available in upstream dams.

TABLE 13-4 ALTERNATION OF HYDROLOGIC REGIME AT UPSTREAM DAMSITE

Month	Plenty Year (1983)			Ordinary Year (1972)			Droughty Year (1979)		
	Before	After	Balance	Before	After	Balance	Before	After	Balance
April	0.00	19.69	19.69	0.69	1.00	0.31	0.00	9.77	9.77
	0.00	17.63	17.63	0.80	1.00	0.20	0.00	1.23	1.23
	0.00	12.18	12.18	0.50	1.00	0.50	0.00	1.00	1.00
May	0.00	1.00	1.00	0.29	1.00	0.71	0.36	1.00	0.64
	0.00	1.00	1.00	0.09	1.66	1.57	0.26	1.00	0.74
	0.00	1.10	1.10	0.04	3.59	3.55	0.18	1.10	0.92
June	1.33	1.00	▲ 0.33	2.11	1.00	▲ 1.11	4.05	1.00	▲ 3.05
	1.10	1.00	▲ 0.10	0.94	1.00	0.06	10.66	1.00	▲ 9.66
	0.56	1.00	▲ 0.44	1.16	1.00	▲ 0.16	6.63	1.00	▲ 5.63
July	3.21	1.00	▲ 2.21	1.24	1.00	▲ 0.24	21.97	1.00	▲ 20.97
	3.07	1.00	▲ 2.07	0.41	1.00	0.59	20.14	1.00	▲ 19.14
	5.06	1.10	▲ 3.96	0.18	5.44	5.26	29.61	1.10	▲ 28.51
August	26.17	1.00	▲ 25.17	1.11	3.89	2.78	18.81	1.00	▲ 17.81
	41.07	1.00	▲ 40.07	12.08	14.10	2.02	15.37	7.28	▲ 8.09
	21.36	1.10	▲ 20.26	5.15	17.73	12.8	9.17	1.10	▲ 8.07
September	36.28	1.00	▲ 35.28	42.21	1.00	▲ 41.21	23.47	1.00	▲ 22.47
	30.37	1.00	▲ 29.37	67.84	1.00	▲ 66.84	57.21	1.00	▲ 56.21
	40.35	1.00	▲ 39.35	52.92	1.00	▲ 51.92	34.62	1.00	▲ 33.52
	53.66	1.00	▲ 52.66	24.05	1.00	▲ 23.05	86.72	1.00	▲ 85.72
October	94.76	23.56	▲ 71.20	19.45	1.00	▲ 18.45	25.42	11.06	▲ 14.36
	46.54	46.43	▲ 0.11	14.89	1.55	▲ 13.34	8.60	22.13	13.53
	5.53	5.43	▲ 0.10	1.07	1.00	▲ 0.07	0.05	9.36	9.31
November	8.04	7.94	▲ 0.10	1.16	1.00	▲ 0.16	0.60	5.59	4.99
	2.56	4.62	2.06	3.39	1.00	▲ 2.39	0.31	9.31	9.00
December	1.96	5.88	3.92	0.60	1.07	0.47	0.20	6.25	6.05
	0.58	12.36	11.78	0.44	5.34	4.90	0.06	12.18	12.12
	0.34	6.55	6.21	0.13	6.57	6.44	0.02	20.93	20.91
January	0.04	10.13	10.09	0.30	10.12	9.82	0.01	19.73	19.72
	0.01	16.32	16.31	0.09	18.49	18.40	0.00	26.21	26.21
February	0.96	3.86	2.90	0.03	25.12	25.09	0.00	29.72	29.72
	0.31	25.28	24.97	0.15	26.59	26.44	0.00	28.17	28.17
	0.37	6.21	5.84	0.01	27.25	27.24	0.00	25.85	25.85
	0.35	6.13	5.78	0.00	21.82	21.82	0.00	20.66	20.66
March	0.12	8.92	8.80	0.00	25.27	25.27	0.00	25.69	25.69
	0.04	16.41	16.37	0.00	15.90	15.90	0.00	11.21	11.21
	0.41	1.83	1.42	0.07	2.62	2.55	0.00	7.45	7.45
Annun	426.5	273.6	▲ 152.9	265.6	251.1	▲ 14.5	374.5	325.1	▲ 49.4

Main kinds of trees: *Lagorstroemia* spp;

Terminalia spp., *Azelia rylocarpa* Craib.

Other kinds of trees: *Irringia malayana* Aliv. spp., *Dialium* spp., *Shorea hemyana* Pierre syn. *S. sericeiflora*, Fish & Flutch, *Delbergia* spp., etc.

Trees mentioned above will be submerged with water after construction of the Si Yat dam. Though tree age and stock volume are not available yet, trees of economical age will be harvested before submerged for the Government revenue. Harvest of young trees are, however, unprofitable.

13-3-3. Quality of Life Values

1) Socio-Economics

The project cost of 8,800 million baht will be invested in seven years 1992 to 1998. After completion of the project, benefits will be extended to 9,660 of farm households and 54,500 persons of population in agriculture sector and to about 120,000 of service population in drinking water sector. Establishment of Ploang Yao Industrial Estate will be promoted by supply of raw water from the Si Yat storage dam.

Development of infrastructure for agricultural production, industrial production and social life will effect important impact on environmental situation in each sector.

As regards environment on production, expansion of cropping intensity owing to improvement of stable irrigation water supply, conversion of cassava to fruits and protection of local flood damage are expected.

Environmental impacts on social life are represented by the upgrading sanitary standard expansion of job opportunity, improvement of water quality in the Tha Lat main irrigation canal etc.

As for transportation, mobility of local inhabitants, generation of motorization/mass marketability through use of O & M road along the new main irrigation canal and the access road will be expected.

2) Resettlement/Compensation

The resettlement program is considered as an important step to the project implementation with the intention of mitigating the impacts on quality of life values of the reservoir evacuees. According to the RID's socio-economic survey in cooperating with JICA staff, the estimate of prospective resettlers is about 700 households. By applying 15 rai land allotted to each resettlers, the

size of resettlement area will be as large as 20 km² including public area for common facilities.

According to the preliminary study on submergence condition, a number of villages will be partially inundated. If possible, the proposed resettlement area should be very close to the reservoir area so that the resettlers can connect normally with their relatives and neighbours living in the non-flooded villages.

Compensation for inundated/affected properties is another problem concerned because most of the inundated villagers have no legal certificate on their own land, thus they will not receive compensation money for this type of inundated land. In total, there are six types of both legal and habitual land ownership. However, their movable properties including houses, fruit trees, crops, animal shelter, fence, well, etc. will be compensated for, even if they do not have formal land ownerships.

Part from private properties, there are also government properties that require compensation money, i.e., reforest plantation by Thai Plywood company. For the affected public or governmental properties that will be newly provided at the resettlement site, the compensation money will not be paid.

Assets to be compensated in Phase II Project are land, fruit trees and structure lost construction of Si Yat dam and main irrigation canal.

Compensation cost is estimated at 400 million baht excluding physical and price contingencies.

Number of farm households to be removed due to construction of Si Yat reservoir are estimated at about 675, about 83% of which desires to move to the resettlement project area prepared by the Government.

It is recommended that the resettlement project area should be selected in Ban Nong Pru Kan Yong, Ban Thung Yai Chi and Ban Wang Wong in Tambon Tha Kialo where irrigation water pumped up from the right bank of the main irrigation canal will be available.

Resettlement cost is estimated at 280 million baht.

13-4. TERM OF REFERENCE FOR FURTHER FULL-SCALE EIS STUDY

Specific objectives of the detailed environmental study for the subject Project are as follows :

- To identify the study areas which would be directly and indirectly affected by the implementation of the proposed Project.
- To describe the existing characteristics and quality of concerned environmental resources/values (ER/V) of the study area.
- To evaluate and predict the short and long term impacts of the proposed Project upon the ER/V, including the definition of degree of significance and magnitude of the predicted impacts. This assessment should be made for the cases :(1) individual damsite Khlong Si Yat dam and Bang Pakong diversion dam separately and (2) integrated effects of both damsites.
- To prepare recommendation on compensation and resettlement plan.

In order to fulfill the above requirements, a term of reference for the farther full-scale Environmental Impact Statement Study has been prepared. Table 13-5 summarizes the implementation of the proposed Phase I Sub-project.

TABLE 13-5 TASKS TO BE CARRIED OUT FOR ENVIRONMENTAL IMPACT ASSESSMENT OF BANG PAKONG DIVERSION

Environmental Component	Data Collection	Review	Field Observation	Field Survey	Data Analysis	Effect Evaluation	Recommendation
1. Physical Resources							
1.1 Surface Water Hydrology	X	✓	✓	NN	NN	✓	✓
1.2 Surface Water Quality	✓	✓	✓	✓	✓	✓	✓
1.3 Erosion	✓	✓	✓	NN	✓	✓	✓
1.4 Soils in irrigation Area	X	✓	✓	NN	NN	✓	✓
2. Ecological Resources							
2.1 Fisheries	✓	✓	✓	✓	✓	✓	✓
2.2 Aquatic ecology	✓	✓	✓	✓	✓	✓	✓
3. Human Use Values							
3.1 Aquiculture	✓	✓	✓	✓	✓	✓	✓
3.2 Water Supply	PA	✓	✓	NN	PA	✓	✓
3.3 Irrigation/drainage	PA	✓	✓	NN	PA	✓	✓
3.4 Navigation	✓	✓	✓	✓	✓	✓	✓
3.5 Livestock/Industry	✓	✓	✓	✓	✓	✓	✓
4. Quality of Life Values							
4.1 Socio-economic	✓	✓	✓	✓	✓	✓	✓
4.2 Compensation/Resettlement	✓	✓	✓	✓	✓	✓	✓
4.3 Public Health	✓	✓	✓	✓	✓	✓	✓

Notes X = Data available in the feasibility study
 ✓ = Activities to be carried out by Envi. team
 NN = Not necessary as work will be done by the feasibility study team
 PA = Part of data might need further analysis for EIA

13-4-1. Term of Reference for the Phase I Sub-Project

1) Physical Resource

Surface Water Hydrology

After completion of the proposed Bang Pakong diversion dam, the natural river system of Bang Pakong will be considerably altered during dry season in particular. Thus it is proposed to review the change on such hydrologic regime of the river, then describe the overall effect in the mass water balance by months and seasons, including the use of detained water for beneficial purposes, such as drinking, industry, irrigation fishery and river maintenance. Anticipation on degree of impacts depends on inundation of lowland along Bang Pakong river banks and tributaries upstream of the diversion dam, particularly when flash floods occurred. For downstream section, the water level will be slightly higher than the existing one during high tide causing more intrusion into river tributaries. The issues of impacts occurred should also be assessed and mitigation measures are to be recommended.

Surface Water Quality

In addition to the review the results of water quality survey made by NEB as well as by RID during the feasibility study period, supplemental sampling of water for at least 4 stations is recommended. In consideration of the purposes of water utilization under with-project condition, the existing water quality and the sources of water pollution, the water quality parameters to be analyzed area proposed as follows:

Temperature	Conductivity
pH	Nitrate
Turbidity	Phosphate
Calcium	Fluoride
Magnesium	Dissolved Solids
Sodium	Suspended Solids
Potassium	Total Solids
Boron	Dissolve Oxygen
Residual Sodium Carbonate	BOD
Bicarbonate	Hardness
Carbonate	Iron/Manganese
Alkalinity	Heavy Metals (Cu, Zn, Pb, Cd, Cr, Hg)

The description of water quality is then prepared for before and after project implementation including both upstream and downstream of the diversion for monthly and seasonal conditions, including effects of water

detention on physical and biological parameters, organic compounds and pollution parameters such as salinity, dissolved oxygen, BOD, pesticides and heavy metals in particular. The major sources of effluent water which would contaminate Bang Pakong river should be evaluated. Those include, for example, effluent water from Bang Khla and Muang Chachoengsao, swine and poultry farms, shrimp farms, agro-industry and farm drainage. Recommendation on mitigation programs or measures to improve water quality suitable for purposes of water utilization especially for drinking should be provided. A concurrent water quality monitoring program is requested to be developed in particular for upstream of the diversion.

Erosion

Nipa palm has been observed along the Bang Pakong river bank from the Gulf up to about Amphoe Ban Sang Prachinburi. It is anticipated that those upstream Nipa plantation shall be severely disturbed after the project completion, and consequently raising rate of erosion particularly during flood period will be caused. Survey of the existing plantation along the affected area and the description of the areas salient to erosion are requested.

Soil

Soil data in the proposed irrigation area (existing Bang Pakong Left Bank area) including the reconnaissance soil map, land classification for irrigation and soil sampling and monitoring guideline are available at DLD and RID, as already been discussed in the feasibility study report. It is, however, requested to review the pertinent data and studies and describe the potential effects of irrigation water on saline and alkaline soils, if any, as well as probable positive effects on those acid soils.

2) Ecological Resources

Aquatic Ecology

The limnetic oligohaline boundary is unfixed depending on tidal effect and seasonal variation, and functions as an interface between saline water and freshwater organisms. During dry season this limnetic boundary will move far upstream to around the confluence of Nakhon Nayok and Prachinburi rivers, consequently marine to brackish fish and aquatic organisms inhabit throughout the Bang Pakong river. These existing ecosystem will be completely changed after the Project. Therefore it is needed to review previous studies on aquatic ecology of Bang Pakong river and also to make an inventory of aquatic fauna and flora particularly of Nipa Palm upstream and downstream of the diversion dam, reselecting at least 4 sampling stations and monitoring them on monthly basis. Then describe new ecology to be created upstream in particular. Attention must also be paid on the migration behavior of fish and

other aquatic organisms, then describe habitat zoning migrating significance ; if any, including its abundance and diversities.

Fisheries

The investigation on fisheries characteristics carried out by the National Inland Fisheries Institute, Department of Fisheries in 1983 and 1987 (Technical Paper No.30 and No. 74) revealed that fish and other aquatic fauna are still abundant in Bang pakong river, having a tendency to decrease in the near future to be caused by human activities. brackish water fishes in Bang Pakong river usually spawn at the river month, then its fry travels upstream for growing. Thus, fishery survey should be conducted to obtain informations mainly on species composition/ diversity, economic species, primary productivity, rare or endangered species, seasonal change and its significance in terms of both economic and ecology. Describe the anticipated effects of the Project on fisheries. Provision should also be made on the context of fisheries management plan.

3) Human Use Values

Aquiculture

Black tiger shrimp culture is very popular along Bang Pakong river banks downstream of Muang Chachoengsao to Amphoe Bang Pakong. Investigation on the existing characteristics of such aquiculture involving their nature, extent, economic significance, etc, should be carried out. Describe anticipated impact of the project as well as potentials for improvement including prediction of a result from increased salinity value in bang Pakong river, and a provision of adequate freshwater to maintain suitable limit of salinity.

Water Supply

The data on water supply requirements for various purposes including domestic and drinking water supply to urban and rural area, industrial development and aquiculture in addition to irrigation are available in this study report. It is to, however, required review and update the such data in cooperation with the agencies concerned. Describe the impacts on improving availability of the water supply including a consideration of the effects of low flow augmentation and extent of conflicts among water users.

From a view point of raw water quality, its characteristics as well as the sources of water contamination have already been discussed in the Section A : surface water quality. The request is to evaluate specifically the water quality parameters and its trend to cause the water unsuitable for utilization as

water supply. Also recommendation on issues or programs for improved quality of raw water supply should be performed.

Irrigation/drainage

To review, survey and investigate the existing and planned irrigation system, and then describe the anticipated impacts of the Project particularly on drainage practices, increased return flow, river water salinity, the plans for reuse of return flows and on the stream ecology to be changed due to return flow containing residues of fertilizers and toxic chemicals.

Navigation

Navigation in Bang Pakong river have been observed. However supplemental survey on existing navigation characteristics as well as its trend, regarding type of boat, number, purpose and frequency of use, destination, etc. should be undertaken. Also describe anticipated function of the diversion dam on navigation and proposed measures for improvement.

Livestock and Industry

Review pertinent data and investigate the extent/characteristics of livestock in the project area and its vicinity. Particular attention should be paid on their water uses and waste disposal. maps and tables indicating their location and characteristics should also be presented. Describe the potentials for agro-industrial development in the irrigation areas.

4) Quality of Life Values

Socio-Economy

To survey and describe the characteristic of socio-economy of local inhabitant in the area and riparian inhabitants both on the proposed abandoned river channel and downstream. Also to delineate the plans for improving the welfare of the affected population.

Compensation

To estimate the compensation cost for properties to be affected by construction of the diversion dam. The compensation schedule and procedure should also be prepared.

Resettlement

Based on the socio-economic study as well as on the result of negotiation among concerned agencies and those evacuees under the State/RID's policy, the consulting service must cover the survey for probable resettlement site (as needed). Also, the planning and layout on infrastructural

facilities and occupation/agricultural development as well as amount of budget required should be prepared.

Public Health/Sanitation

To investigate and describe health, sanitation and nutritional status of local inhabitants of the upstream and downstream the diversion site and irrigation area. In parallel with the mentioned undertaking, those prevalent/ infecting rates and vectors/ intermediate hosts of water borne diseases should be surveyed/analyzed and described.

It should be noted that there are several swine farms operated in the low lying area, particularly in the vicinity of the proposed irrigation areas, it is requested to review pertinent data/information and investigation/examination should be made regarding the possibility of those swine as an intermediate host of water oriented diseases.

Elaboration of health safeguard/preventive measures is of strong request.

13-4-2. TERM OF REFERENCES FOR THE PHASE II SUB-PROJECT

Considering the major features of Khlong Si Yat Dam regarding reservoir surface water level, effective storage and irrigation area, it is a need for making a full-scale environmental impact study before the project implementation. Table 13-16 depicts the list of environmental issues to be evaluated, with different activities needed.

1) Physical Resource

Climate

Review and analyze the meteorological data in the project area collected from RID, Meteorological Department and other agencies concerned, regarding rainfall, temperature, evaporation and evapotranspiration, wind and humidity. Evaluate potential of the such climatic change particularly on evaporation and evapotranspiration loss from the Khlong Si Yat reservoir.

Surface Water Hydrology

The data on surface water hydrology of Si Yat and Tha Lat rivers have been continuously observed and recorded by RID, and those data concerning to the water resources management of Si Yat reservoir were analyzed and presented in this study report. Review the such hydrologic regime that will be altered by the Project ; including stream flow, flood occurrence, water utilization for different purposes, etc. Then describe the overall effect in the

mass water balance by months and seasons, including the use of stored water for such beneficiaries as the existing Tha lat irrigation and Expansion areas, industrial development at Amphoe Plaeng Yao, water supply at Amphoe Sanamchaikhet and Phanom Sarakham and downstream flow maintenance. Flood mitigation to be achieved by the Project should also be evaluated.

TABLE 13-6. TASKS TO BE CARRIED OUT FOR ENVIRONMENTAL IMPACT ASSESSMENT OF SI YAT DAM

Environmental Component	Data Collection	Review	Field Observation	Field Survey	Data Analysis	Effect Evaluation	Recommendation
1. Physical Resources							
1.1 Climate	X	✓	NN	NN	NN	✓	✓
1.2 Surface Water Hydrology	X	✓	✓	NN	NN	✓	✓
1.3 Surface Water Quality	✓	✓	✓	✓	✓	✓	✓
1.4 Ground water	✓	✓	✓	NN	✓	✓	✓
1.5 Geology	X	✓	✓	NN	NN	✓	✓
1.6 Erosion/Sedimentation	PA	✓	✓	NN	PA	✓	✓
1.7 Soils in Reservoir Area	✓	✓	✓	✓	✓	✓	✓
1.8 Soils in Resettlement	✓	✓	✓	✓	✓	✓	✓
1.9 Soils in Irrigation Area	X	✓	✓	NN	✓	✓	✓
2. Ecological Resources							
2.1 Fisheries/Aquatic Biology	✓	✓	✓	✓	✓	✓	✓
2.2 Forestry/Wildlife/Watershed	✓	✓	✓	✓	✓	✓	✓
3. Human Use Values							
3.1 Land Use/Agriculture	✓	✓	✓	✓	✓	✓	✓
3.2 Irrigation/Water Supply	PA	✓	✓	NN	PA	✓	✓
3.3 Land Transportation	✓	✓	✓	NN	✓	✓	✓
3.4 Navigation	✓	✓	✓	NN	✓	✓	✓
3.5 Mineral Resources	✓	✓	✓	✓	✓	✓	✓
4. Quality of Life Values							
4.1 Socio-economic in Reservoir & Resettlement	✓	✓	✓	✓	✓	✓	✓
4.2 Socio-economic in Irr. Area	X	✓	✓	✓	✓	✓	✓
4.3 Compensation/Resettlement	✓	✓	✓	✓	✓	✓	✓
4.4 Public Health	✓	✓	✓	✓	✓	✓	✓
4.5 Archaeology/Tourism	✓	✓	✓	✓	✓	✓	✓

Notes X = Data available in the feasibility study
 ✓ = Activities to be carried out by Envi. team
 NN = Not necessary as work will be done by the feasibility study team
 PA = Part of data might need further analysis for EIA

Surface Water Quality

The water samples taken from the Si Yat river and analyzed by RID revealed the river still keeps a good quality for both irrigation and water supply purposes. It is requested to make an additional survey on physio-chemical properties of Si Yat water upstream and downstream of the proposed damsite, covering wet and dry season periods. The parameters to be analyzed are in the following :

Flow velocity	Nitrate
Temperature	Phosphate
pH	Fluoride
Turbidity	Dissolved Solids
Calcium	Suspended Solids
Magnesium	Total Solids
Sodium	Dissolved Oxygen
Potassium	Hardness
Boron	Iron/Manganese
Residual Sodium Carbonate	Heavy Metals (Cu, Zn, Pb, Cd, Cr, Hg)
Bicarbonate	Organo Chlorine
Carbonate	Farcal Coliform
Alkalinity	Soluble Sodium Percentage
Chloride	Sodium Absorption Ratio
Sulphate	
Conductivity	

Then, describe existing condition of surface water quality of Si Yat river, including contamination of river water quality by various activities. Also, evaluate the effect of reservoir impoundment on water quality both in the reservoir area and downstream section, particularly water suitability for proposed utilization. Recommendation on appropriate mitigative measures should be made if the water quality tends to be more contaminated, and then make a suggestion on monitoring program also.

Groundwater

Collect and review available information and data on groundwater from the responsible agencies as well as from the field observation both in reservoir vicinity and downstream area. Such data should comprise locations, seasonal water depth, yield, availability, adequacy and water quality. The ground water sampling should be carried out in order to analyze the parameters as proposed in the following :

pH	Iron
Acidity	Manganese
Alkalinity	Nitrate
Hardness	Chloride
Calcium	Magnesium

Then, describe the possibility of increasing groundwater availability in villages around and downstream of the damsite as well as the possibility of reservoir seepage. Recommendation on the possibility of groundwater development in the project vicinity should also be made.

Geology Seismology

This environmental aspects is already studied in details and presented in this study reports. Review and describe the probable effects induced by the Project on possible land slides of reservoir shoreline and possible geological failures or changes caused by dam construction and the impoundment.

Erosion and Sedimentation

It is suggested, for the purpose of adequacy, to make a field observation on erosion in the deforested watershed area and erosion along Si Yat river bank. Evaluation of sediment load on the expected effective capacity of the reservoir as well as recommendation on the plans or measures to minimize erosion and sedimentation should be performed or provided.

Soils

Survey investigate and describe soil suitability classification particularly for irrigated crops in the existing Tha Lat irrigation area and expansion area. Also, conduct permeability test of the irrigated soils at well-distributed sampling stations over the project area. Anticipated positive and negative effects of providing irrigation water on soil quality including acid and saline/alkaline soils as well as recommendation on measures to mitigate negative effects, if any, should be studied.

Regarding the proposed resettlement site, the under taking is to survey the soil characteristics then describe its suitability/capability for different drops and present the results in a form of into a map and table.

2) Ecological Resources

Fisheries/Aquatic Ecology

The following activities are proposed for assessment :

- To conduct the field sampling program for collection of information of information on aquatic ecology including plankton, benthos, weeds and fish population in Si Yat river.
- To survey fishing activities as well as aquaculture in the project area.

- To describe new ecology to be expected in the reservoir including new fishery to be created and the plan for its management, thermal stratification and eutrophication phenomena, and change on plankton and benthos productivity.
- To describe effect of Project on downstream aquatic biology and fisheries, including effects of nutrient trapping in the reservoir and effects of the dam in interfering with migratory species.
- To study fisheries benefit to be increased in the reservoir and the losses to be caused in downstream fisheries.
- To recommend the monitoring program and fishery/aquiculture enhancement program for the Si Yat reservoir.

Forestry/Wildlife and Watershed Management

To conduct a field survey/observation and collect data in the proposed reservoir area and vicinity in the resettlement site, and to investigate the current condition on forest ecology, wildlife and illegal hunting in the watershed. Describe the present and future status of the forest in the Khlong Si Yat watershed, and its role in soil and water conservation as well as proposed measures for preserving this role. Evaluate the impact of the project on inundating forest reserves including the estimates of loss forests through improved access and communities. The impacts of the project on wildlife in the watershed area and on fauna to be inundated and the plans for salvaging and rehabilitation should also be assessed. Besides, the recommendation on the need for reforestation and watershed rehabilitation, forest/wildlife conservation and protection should also be elaborated.

3) Human Use Values

Land Use and Agriculture

Survey and describe the existing land use and agricultural development in the reservoir area and its vicinity, irrigation area and resettlement site. Evaluate the opportunity loss of land due to inundation, the change of land use pattern in the resettlement and surrounding areas and the land utilization and benefit in the irrigation area including cropping patterns, productivity and freshwater fish culture in the southern part of Tha Lat irrigation area.

Irrigation / Water Supply

Review and analyze the existing irrigation and drainage systems as well as proposed ones for improvement/expansion discussed in this feasibility study report. Then describe the potential impacts by the project, including

adequacy of drainage facilities, effects of increased/provided irrigation water on soil characteristics and on normal practice of farming, and effects on increased pesticide/insecticide causing contamination in return flow and further change in water ecology downstream.

The impacts on improving availability of the water supply for communities downstream, Amphoes Sanam Chaikhet and Phanom Sarakham, as well as industrial development at Plaeng Yao, taking into consideration of water quality, should be investigated.

Land Transportation/Navigation

Survey and describe the effect of project on probable alternation of land transportation and navigation in upstream and downstream areas : for example, plan for road relocation due to inundation, trouble of traffic due to construction, development of communities caused by improved access road, trouble on navigation in Khlong Si Yat if any, and possibility of navigation in the proposed reservoir area.

Mineral Resource

Review relevant data/documents on geological characteristics and conduct ground survey in the reservoir area and vicinity for the purposed of evaluation of mineral deposits. Also, describe the potential of mineral development, if any.

4) Quality of Life Values

Socio-Economy

Review the preliminary socio-economic investigation conducted by RID during the feasibility study and undertake additional field survey with questionnaire at the proposed reservoir and resettlement areas. Evaluate their existing socio-economic status and cultural condition, negative/positive socio-economic changes to be caused by the project and their attitudes toward the project development. Recommendation on proper plan/method of evacuation, compensation and resettlement should be delineated. The necessary socio-economic inputs for improving the welfare of the resettlers should also be described.

Compensation/Resettlement

To survey the properties in the Si Yat reservoir area and formulate the compensation concepts, payment schedule, procedure, compensation rate and cost estimations. Regarding resettlement aspects, it is requested to summarize the number of reservoir evacuee that need to join the proposed resettlement site. Survey the possible resettlement site on its physical agricultural and

socio-economic suitability ; then, formulate development plan of the selected resettlement site, including village layout, infrastructural planning and agricultural development planning as well as estimation of associated costs. Evaluation of probable environmental effects of the proposed resettlement schemes should also be made involving effects on forest clearing and wildlife disturbance, increased erosion/sedimentation due to site development, conflicts with existing inhabitants and effects on public health status.

Public Health / Nutrition

To conduct a survey on public health/nutrition status of residents in the Si Yat reservoir, proposed resettlement area and irrigation area, as well as vector survey for specific health problems related water resource development particularly vector-borne and snail-borne diseases. Then, analyze and evaluate alteration of the prevalence/infection rates of major diseases and their vectors or intermediate hosts due to the project development as well as effects of reservoir fisheries on nutrition status of local people. The recommendation on mitigation/enhancement measures and monitoring program should also be performed with the main aim for the improvement of existing health conditions of Si Yat reservoir evacuees.

Archaeological Values

To review and investigate archaeological/historical/religious values existing in the proposed Si Yat reservoir area and its vicinity. Then, describe the significance of the sites and artifacts found, and recommend their potential relocation/preservation of rehabilitation programs for various purposes.

A esthetics / Tourism

To conduct a survey on tourist characteristics and tourism markets of the proposed project vicinity. Evaluation of esthetic quality and tourism potential of Si Yat reservoir, including tourism benefit, as well as identification of adverse environmental effects resulting from the such tourism development should also be assessed. Also the recommendation on tourism promotion program within the vicinity of Si Yat reservoir taking into consideration the Chachoengsao tourism promotion plan should be elaborated.

**CHAPTER 14. CONCLUSIONS AND
RECOMMENDATIONS**

CHAPTER 14. CONCLUSION AND RECOMMENDATION

14-1 Conclusion

As a result of the overall basin study for the agricultural water resources development project of Bang Pakong river basin, the Tha Lat river basin project was selected as the one with top priority from several sub-basin development projects.

Continuously, the feasibility study on the project has been made carefully. The project has multi-purposes for water resources development, that is, for irrigation, industry, drinking, and fisheries, and two sub-phased implementation schedules.

As stated above, it has been found that the project is accorded high priority and great urgency to be developed with water supply for attaining quick benefits to the project area and accelerating regional development.

It is, therefore, concluded that after its prudent findings, the Project is technically feasible and economically viable.

14-2 Recommendation

1) In the time of the implementation of the Tha Lat river basin development project with storage dam and diversion dam constructions, not only the technical and economic examinations, but also social or environmental considerations must inevitably be needed according to the result of the environmental impact study to be carried out by the third party.

2) The facilities plan and their cost estimation made in this feasibility study must be reexamined at the detailed design stage to enhance their precision.

3) The organization of the project implementation and their operation and maintenance must be strongly functioned, because of multipurpose water resources development schemes and multi-phased implementation programs.

- 4) Especially, the control of the water to be released from the dams and the diversion dam after construction will be quite important. It must be unifiedly controlled by the technical officials of the government.
- 5) The water management board on a provincial level should be organized to coordinate the water distribution plan based on the water demand request from respective sectors for effective utilization of water resources.
- 6) The project implementation schedule must be phased in conformity to water demand tendency, urgency of water supply policy, effectiveness of investment, etc.
- 7) The resettlement areas for Khlong Si Yat dam and Bang Pakong diversion dam must be finally determined after the more detailed investigation and study.
- 8) Based on the understanding of the basic concept in which irrigation and drainage must be separated each other, the irrigation and drainage plans must be implemented. Besides, RID should educate and cooperate farmers to be benefited to implement construction works and proper operation/maintenance of the terminal irrigation and drainage facilities in order to execute quick yielding of the proposed crop productions.
- 9) So as to bring the cultivation technic of diversification crops and transportation system on a higher level, administratively and financially assisting countermeasures for such agricultural supporting services as agricultural extension, farmers' organization, credit, circulating system, etc. will be required.
- 10) The diversion dam works to be implemented near the existing communities require the treatment of plenty of dredged soil. Acquisition of the land to fill up the soil and how to use the filled land must be seriously examined.
- 11) Since the construction of conducting facilities for industrial and domestic water supplies is concurred with the construction of the diversion dam and

irrigation facilities, scrupulous coordination will be necessary for implementing the project harmoniously and economically.

12) The topographic survey and geological investigation must be carried out for further detailed design, land acquisition and construction works.

- Topographic surveys for storage and diversion damsite and main irrigation/drainage facilities.
- Geological investigations for storage and diversion dams and major facilities related.

13) Since the arrears of the planned construction schedule influence upon the economy of the investment, the construction works on time will be inevitably needed.

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